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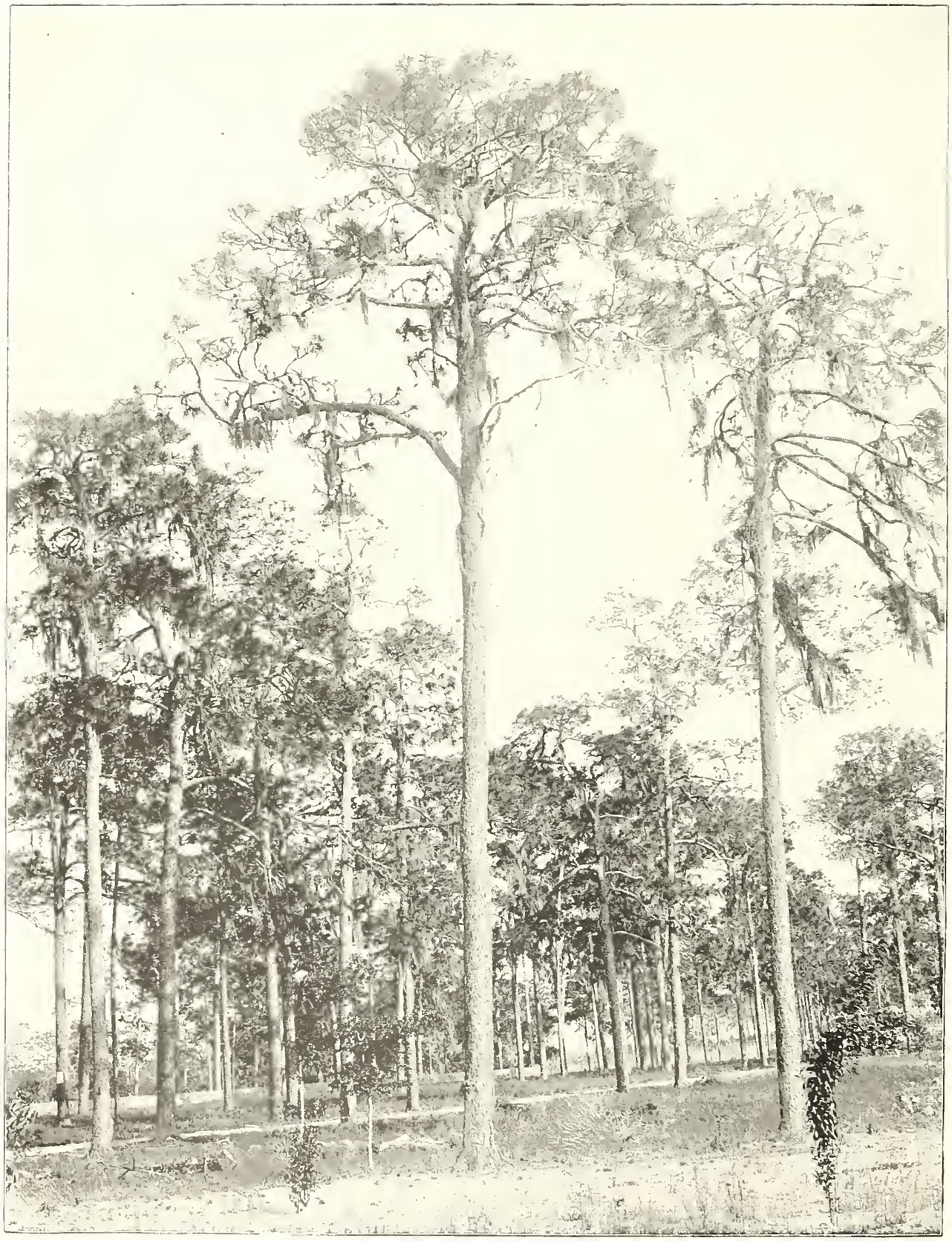

LONGLEAF PINE (PINUS PALUSTRIS).

BULLETIN No. 13.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

THE TIMBER PINES OF THE SOUTHERN UNITED STATES.

By CHARLES MOHR, Ph. D.

TOGETHER WITH

A DISCUSSION OF THE STRUCTURE OF THEIR WOOD.

By FILIBERT ROTH.

PREPARED UNDER THE DIRECTION OF B. E. FERNOW, CHIEF OF THE DIVISION OF FORESTRY.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
Washington, D. C., May 26, 1896.

SIR: I have the honor to submit herewith for publication a series of monographs on the five pines of economic importance in the Southern United States, a result of many years' study by Dr. Charles Mohr, the well-known authority on the botany of the Southern States and agent of the Division of Forestry.

The first draft of these monographs was prepared several years ago, but it was then found that in order to make them fully satisfactory and useful to the practitioner much additional information was needed, especially regarding the rate of growth and other sylvicultural as well as technological questions. This information has been gradually accumulated as our facilities have permitted. The extended investigations carried on in this division may be considered quite exhaustive, especially in regard to the mechanical properties of the wood of these pines. An interesting chapter on the wood structure by Mr. Filibert Roth has been added, and a comparative study of the economic, sylvicultural, and technical characteristics and value of the pines under consideration—a résumé, as it were, of the contents of the monographs—is to be found in the introduction by the writer.

The pineries of the South furnish now, or will in the near future, the most important staples of our lumber industry. According as they are treated, carefully or wastefully, they will continue for a longer or shorter time to be a wealth-producing resource of the South. To aid in securing a true conception of the extent, condition, and value of this resource, and of the nature, development, characteristics (botanical, sylvicultural, and technological) of these pines, these monographs have been written, with the hope of inducing rational forestry methods in their use and reproduction.

Respectfully,

B. E. FERNOW,
Chief of Division.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

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INTRODUCTION.

In ignorance of the nature and without appreciation of the economic value of their resources, pioneers squander and destroy without regard to the future the riches they find. We have done so in the United States and are continuing to do so although the pioneering stage should have been passed, especially with our forest resources. We have exploited them as if they were mines, instead of crops which can be harvested and reproduced continuously, and we have done so in a most wasteful manner; nay, we have by irrational methods of exploitation, no doubt due in part to the necessities of a rapidly developing country, in many cases destroyed the conditions for natural reproduction of the more valuable timber species. Fire and indiscriminate pasturing have also assisted in the process of deterioration.

We are just beginning to realize that our timber supplies are not unlimited; that our magnificent forest resources have been despoiled and need at least more consideration; that sooner or later forestry will become, nay, is now, a necessity.

Forestry is the art of producing, managing, and harvesting wood crops. To be successful in this art it is of course necessary to understand the nature of the crop—to be acquainted with the life history, the conditions of development required by each species of tree composing the crop. Such knowledge can be in part, at least, derived from observations made in the natural forests, and from these observations the manner in which the different species should be treated and rules of management may be determined.

The time for the application of forestry—that is, rational methods of treating the wood crop—has not, as many seem to suppose, come only when the natural forest growths have been despoiled and deteriorated. On the contrary, when the ax is for the first time applied, then is the time for the application of forestry, for it is possible so to cut the original natural forest crop that it can reproduce itself in a superior manner. The judicious and systematic use of the ax alone, in the hands of the forester, will secure this result.

Hence these monographs on the life history of the Southern pines have been written primarily to enable the owners of Southern pineries, who are now engaged in exploiting them, to so modify their treatment of the same as to insure continued reproduction instead of complete exhaustion, which is threatened under present methods.

The pines are the most important timber trees of the world. They attain this importance from a combination of properties. In the first place, they possess such qualities of strength and elasticity, combined with comparatively light weight and ease of working, as to fit them specially for use in construction which requires the largest amount of wood; next, they occur as forests in the temperate zones, often to the exclusion of every other species, so that their exploitation is made easy and profitable; thirdly, they are readily reproduced and tolerably quick growers; and, lastly, they occupy the poorest soils, producing valuable crops from the dry sands, and hence are of the greatest value from the standpoint of national economy.

The Southern States abound in those sandy soils which are the home of the pine tribes and were once covered with seemingly boundless forests of the same. There are still large areas untouched, yet the greater portion of the primeval forest has not only been culled of its best timber, but the repeated conflagrations which follow the lumbering, and, still more disastrously, the turpentine gatherers' operations have destroyed not only the remainder of the original growth, but the vegetable mold and the young aftergrowth, leaving thousands of square miles as blackened wastes, devoid of usefulness, and reducing by so much the potential wealth of the South.

There are, in general, four belts of pine forest of different types recognizable, their boundaries running in general direction somewhat parallel to the coast line: (1) The coast plain, or pine-barren flats, within the tidewater region, 10 to 30 miles wide, once occupied mainly by the most valuable

of Southern timbers, the Longleaf Pine, now being replaced by Cuban and Loblolly Pines; (2) the rolling pine hills, or pine barrens proper, with a width of 50 to 120 miles, the true home of the Longleaf Pine, which occupies it almost by itself; (3) the belt of mixed growth of 20 to 60 miles in width, in which the Longleaf Pine loses its predominance, the Shortleaf, the Loblolly, and the hard woods associating and disputing territory with it; and (4) the Shortleaf Pine belt, where the species predominates on the sandy soils, the Longleaf being entirely absent and the Loblolly only a feeble competitor, hard woods being interspersed or occupying the better sites. Within the territory the species that occur occupy different situations. Thus the Cuban, which accompanies the Longleaf, usually occupies the less well-drained situations, together with the Loblolly, which, although it can accommodate itself to all soils, reaches its best development in the rich lowlands and is specially well developed in the flat woods which border the coast marshes of eastern Texas, where it associates with the Shortleaf Pine it also seeks the moister situation.

The Longleaf and Shortleaf pines are, in quantity and quality combined, the most important, while the Loblolly or Oldfield Pine, as yet not fully appreciated, comes next, occupying large areas. The Cuban Pine, usually known as Slash Pine—always cut and sold without distinction with the Longleaf Pine—a tree of as fine quality and of more rapid growth than the Longleaf Pine, is associated with the latter in the coast pine belt, scattered in single individuals or groups, but appears to increase in greater proportion in the young growth, being by its manner of development in early life better fitted to escape the dangers to which the aftergrowth is exposed.

Besides these four most important pines, there are a number of others of less significance. The White Pine (*Pinus strobus*) of the North extends its reign along the higher mountain regions of North Carolina into Georgia, forming a valuable timber tree, but of small extent. The Spruce Pine, to which a short chapter is devoted in this bulletin, develops into timber size, but is found only in small quantities and mostly scattered, and has therefore as yet not received attention in lumber markets; but its qualities, and especially its forestal value, being a pine which endures shade, will probably be appreciated in the future. The other four species of pine found in the South, which appear in the table below, which gives their botanical distinctions, do not develop into timber trees of value, excepting that the Scrub Pine, occupying large areas of abandoned fields in Virginia, furnishes a considerable amount of firewood.

BOTANICAL DIAGNOSIS OF THE FOUR PRINCIPAL PINES OCCURRING IN THE SOUTHERN STATES.

Species.	*Pinus palustris* Miller.	*Pinus heterophylla* (Ell.) Sudw.
Leaves	Three in a bundle, 9 to 12 (exceptionally 14 to 15) inches long.	Two and three in a bundle; 7 to 12 (usually 9 to 10) inches long.
Cones (open)	6 to 9 inches long, 4½ to 5 inches in diameter.	4 to 6½ (usually 4 to 5) inches long; 3 to 4¾ inches in diameter.
Scales	Seven-eighths to 1 inch broad; tips much wrinkled; light chestnut brown; gray with age.	Eleven-sixteenths to seven-eighths inch broad; tips, wrinkled; deep russet brown; shiny.
Prickles	Very short, delicate, incurved.	Very short; straight; declined.
Buds	Three-fourths inch long, one-half inch in diameter, silver white.	About one-half inch long; one-fourth inch in diameter; brownish.

Species.	*Pinus echinata* Miller.	*Pinus taeda* Linn.
Leaves	Two and three in a bundle; 1⅜ to 4 inches long; commonly 2½ to 4 inches.	Three in a bundle; 5 to 8 inches long.
Cones (open)	1½ to 2 inches long; 1⅛ to 1¾ inches in diameter.	2½ to 4½ inches long; 1¾ to 3 inches in diameter.
Scales	Five-sixteenths to three-eighths (exceptionally about one-half) inch broad; tips light yellow-brown.	Three-eighths to three-fourths inch broad; tips smooth; dull yellow-brown.
Prickles	Exceedingly short (one-tenth inch); delicate; straight; declined.	Short; stout at base.
Buds	Three-eighths to one-half inch long; about one-eighth inch in diameter; brownish.	One-half to three-fourths inch long; one-fourth inch in diameter; brownish.

The greatest confusion exists with regard to the vernacular names of these pines, in consequence of which information regarding them, given by the native population, must always be carefully scrutinized to determine exactly to what species it refers. Even in the lumber market and among wood consumers, engineers, architects, and carpenters the same confusion exists; Longleaf and Cuban pines are never distinguished; Shortleaf and Loblolly pines are mixed indiscriminately, and often "Southern Pine," or "Yellow Southern Pine," satisfies the specification of the architect and may come from any of the four species.

To assist in clearing this confusion the following synopsis of botanical and vernacular names is here inserted:

NOMENCLATURE OF SOUTHERN PINES.

Botanical names.....	*Pinus palustris* Miller. Syn.: *P. australis* Michx.	*Pinus echinata* Miller. Syn.: *Pinus mitis* Michx. *P. virginiana* var. *echinata* Du Roi. *P. tæda* var. *variabilis* Aiton. *P. variabilis* Lamb. *P. rigida* Porcher.	*Pinus tæda* Linn. Syn.: *Pinus tæda* var. *tenuifolia* Aiton.	*Pinus heterophylla* (Ell.) Sudw. Syn.: *Pinus tæda* var. *heterophylla* Ell. *P. elliotii* Engelm. *P. cubensis* var. *terthrocarpa* Wright.
Best common names.	LONGLEAF PINE.	SHORTLEAF PINE.	LOBLOLLY PINE.	CUBAN PINE.
Local, market, and lumbermen's names.	Southern Yellow Pine. Southern Hard Pine. Southern Heart Pine. Southern Pitch Pine. Hard Pine (Miss., La.). Heart Pine (N. C. and South Atlantic). Pitch Pine (Atlantic). Longleaved Yellow Pine (Atlantic). Longleaved Pine (Atlantic). Longleaved Pitch Pine (Atlantic). Longstraw Pine (Atlantic). North Carolina Pitch Pine. Georgia Yellow Pine. Georgia Pine. Georgia Heart Pine. Georgia Longleaved Pine. Georgia Pitch Pine. Florida Yellow Pine. Florida Pine. Florida Longleaved Pine. Texas Yellow Pine. Texas Longleaved Pine.	Yellow Pine (N. C., Va.). Shortleaved Yellow Pine. Shortleaved Pine. Virginia Yellow Pine (in part). North Carolina Yellow Pine (in part). North Carolina Pine (in part). Carolina Pine (in part). Slash Pine (N. C., Va.), in part. Oldfield Pine (Ala., Miss.). Bull Pine (?). Spruce Pine.	Slash Pine (Va., N. C.), in part. Loblolly Pine (Gulf region). Oldfield Pine (Gulf region). Rosemary Pine (N. C., Va.). Shortleaved Pine (Va., N. C., S. C.). Bull Pine (Texas and Gulf region). Virginia Pine. Sap Pine (Va., N. C.). Meadow Pine (Fla.). Cornstalk Pine (Va.). Black Pine (Va.). Foxtail Pine (Va., Md.). Indian Pine (Va., N. C.). Spruce Pine (Va.), in part. Bastard Pine (Va., N. C.). Yellow Pine (No Ala., N. C.). Swamp Pine (Va., N. C.). Longstraw Pine (Va., N. C., Ark.), in part.	Slash Pine (Ga., Fla.). Swamp Pine (Fla. and Ala.), in part. Bastard Pine (Fla., Ala.). Meadow Pine (Fla., E. Miss), in part. She Pitch Pine (Ga.).

While it is easy enough to recognize the species in the field by their botanical characters, it is difficult and often impossible to distinguish them in the wood by mere macroscopic inspection or examination with the magnifier and without the aid of the microscope, nor are the microscopic features so far recognized sufficient for specific distinction.

A long-continued study of these woods by Mr. Filibert Roth, of the Division of Forestry, has not developed any characteristics which would be always reliable in distinguishing the species. The best that can be done is to give a synopsis of characters, by which they differ generally when larger quantities, as in the log or lumber pile, are under inspection.

CHARACTERISTICS OF THE WOOD OF SOUTHERN PINES.

Diagnostic features of the wood.

Name of species.	Longleaf Pine (*Pinus palustris* Miller).	Cuban Pine (*Pinus heterophylla* (Ell.) Sudw.).
Specific gravity of kiln-dried wood. Possible range	.50 to .90	.50 to .90
Specific gravity of kiln-dried wood. Most frequent range	.55 to .65	.55 to .70
Weight, pounds per cubic foot, kiln-dried wood, average.	36	37
Character of grain seen in cross section	Fine and even; annual rings quite uniformly narrow on large logs, averaging generally 20 to 25 rings to the inch.	Variable and coarse; rings mostly wide, averaging on larger logs 10 to 20 rings to the inch.
Color, general appearance	Even dark reddish-yellow to reddish-brown.	Dark straw color, with tinge of flesh color.
Sapwood, proportion	Little; rarely over 2 to 3 inches of radius.	Broad, 3 to 6 inches.
Resin	Very abundant; parts often turning into "light wood;" pitchy throughout.	Abundant, sometimes yielding more pitch than Longleaf; "bleeds" freely, yielding little scrape.

Name of species.	Shortleaf Pine (*Pinus echinata* Miller).	Lobolly Pine (*Pinus tæda* Linn.).
Specific gravity of kiln-dried wood. Possible range	.40 to .80	.40 to .80
Specific gravity of kiln-dried wood. Most frequent range	.45 to .55	.45 to .55
Weight, pounds per cubic foot, kiln-dried wood, average.	30	31
Character of grain seen in cross section	Very variable; medium, coarse; rings wide near heart, followed by zone of narrow rings; not less than 4 (mostly about 10 to 15) rings to the inch, but often very fine-grained.	Variable, mostly very coarse; 3 to 12 rings to the inch, generally wider than in shortleaf.
Color, general appearance	Whitish to reddish-brown	Yellowish to reddish and orange brown.
Sapwood, proportion	Commonly 2 to 4 inches of radius	Very variable, 3 to 6 inches of the radius.
Resin	Moderately abundant, least pitchy; only near stumps, knots, and limbs.	Abundant; more than Shortleaf, less than Longleaf and Cuban, but does not "bleed" if tapped.

It is clear from the above diagnosis that Longleaf Pine may be distinguished from Cuban Pine by its finer grain and small amount of sapwood; also that both of these differ from the Shortleaf and Loblolly in their greater weight and the more resinous character of their wood, but that the wood of the two last-named species is rarely distinguishable beyond doubt.

Technically the wood of the pines differs about as follows: The wood of the Longleaf and Cuban pines are about equal in strength, Longleaf excelling by its finer grain and smaller amount of sapwood. The same comparison may be made with regard to Loblolly and Shortleaf Pine. Being much more variable, however, in weight and grain, exceptions to the general rule here are very numerous. Of the last-named species it may be said that the wood derived from more southern localities is generally heavier and stronger than northern grown—a fact especially apparent in the case of the Shortleaf Pine.

The extensive investigations carried on by the Division of Forestry during the last three to four years mainly on these pines permit us to give the following résumé of their mechanical properties derived from not less than 20,000 tests and as many measurements and weighings. We quote this information from Circular 12 of the division:

MECHANICAL PROPERTIES.

In general the wood of all these pines is heavy for pine (31 to 40 pounds per cubic foot, when dry), soft to moderately hard (hard for pine), requiring about 1,000 pounds per square inch to indent one-twentieth inch; stiff, the modulus of elasticity being from 1,500,000 upward; strong, requiring from 7,000 pounds per square inch and upward to break in bending and over 5,000 pounds in compression when yard-dry.

The values given in this circular are averages based on a large number of tests from which only defective pieces are excluded.

In all cases where the contrary is not stated the weight of the wood refers to kiln-dried material and the strength to wood containing 15 per cent moisture, which may be conceived as just on the border of air-dried condition. The first table gives fairly well the range of strength of commercial timber.

Average strength of Southern Pine.

[Air-dry material (about 15 per cent moisture).]

Name.	Compression strength.					Bending strength.							Tensile strength per square inch.	Shearing strength per square inch.
	With grain.				Across grain (3 per cent indentation), per square inch.	At rupture modulus $\frac{3\,W\,l}{2\,b\,h^2}$.				At elastic limit modulus $\frac{3\,W_1\,l}{2\,b\,h^2}$ per square inch.	Elasticity (stiffness) modulus $\frac{3\,W\,l^3}{4\,\Delta\,b\,h^3}$ per square inch.	Relative elastic resilience, per cubic inch.		
	Average of all valid tests.		Average for the weakest one-tenth of all the tests.			Average of all valid tests.		Average for the weakest one-tenth of all the tests.						
	Absolute, per square inch.	Relative.	Absolute, per square inch.	Relative.		Absolute, per square inch.	Relative.	Absolute, per square inch.	Relative.					
	Pounds.		*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*		*Pounds.*	*Pounds.*	*Pounds.*	*Lbs.*	*Lbs.*
Cuban Pine	7,850	100	6,500	100	1,050	11,950	100	8,750	100	9,450	2,305,000	2.5	14,300	680
Longleaf Pine	6,850	87	5,650	87	1,060	10,900	91	8,800	101	8,500	1,890,000	2.3	15,200	706
Loblolly Pine	6,500	83	5,350	82	990	10,100	84	8,100	92	8,150	1,950,000	2.25	14,400	690
Shortleaf Pine	5,900	75	4,800	74	940	9,230	77	7,000	80	7,200	1,600,000	2.05	13,400	688

RELATION OF STRENGTH TO WEIGHT.

The intimate relation of strength and specific weight has been well established by the experiments. The average results obtained in connection with the tests themselves were as follows:

	Cuban.	Longleaf.	Loblolly.	Shortleaf.
Transverse strength	100	91	84	77
Specific weight of test pieces	100	94	82	77

Since, in the determination of the specific gravity above given, wood of the same per cent of moisture (as is the case of the values of strength) was not always involved, and also since the test pieces, owing to size and shape, can not perfectly represent the wood of the entire stem, the following results of a special inquiry into the weight of the wood represents probably more accurately the weight and with it the strength relations of the four species.

WEIGHT RELATIONS.

[These data refer to the average specific weight for all the wood of each tree, only trees of approximately the same age being involved.]

	Cuban.	Longleaf.	Loblolly.	Shortleaf.
Average age of trees.....years..	171	127	137	131
Number of trees involved.....	6	22	14	10
Specific gravity of dry wood.....	0.63	0.61	0.53	0.51
Weight per cubic foot.....pounds..	39	38	33	32
Relative weight	100	97	84	81
(Transverse strength *).....	(100)	(91)	(84)	(77)

*The values of strength refer to all tests, and therefore involve trees of wide range of age and consequently of quality, especially those of Longleaf; involve much wood of old trees, hence the relation of weight and strength appears less distinct.

From these results, although slightly at variance, we are justified in concluding that Cuban and Longleaf Pine are nearly alike in strength and weight and excel Loblolly and Shortleaf by about 20 per cent. Of these latter, contrary to common belief, the Loblolly is the heavier and stronger.

The weakest material would differ from the average material in transverse strength by about 20 per cent, and in compression strength by about 30 to 35 per cent, except Cuban Pine, for which the difference appears greater in transverse and smaller in compression strength. It must, of course, not be overlooked that these figures are obtained from full-grown trees of the virgin forest, that strength varies with physical conditions of the material, and that therefore an intelligent inspection of the stick is always necessary before applying the values in practice. They can only represent the average conditions for a large amount of material.

DISTRIBUTION OF WEIGHT AND STRENGTH THROUGHOUT THE TREE.

Weight and strength of wood at different heights in the tree.

	Strength of Longleaf Pine (pounds per square inch).		Specific weight.			Mean of all three species (relative weight).	Relative strength of Longleaf Pine (mean of compression and bending).
	Bending strength.	Compression endwise (with grain).	Longleaf.	Loblolly.	Shortleaf.		
Number trees used.....	56		22	14	12	48	56
Average age of trees.....	150 (over)		127	113	131	.....	.....
Number of feet from stump:							
0	.....	.....	.751	.629	.614	.....	.....
			106	*106*	*105*	*106*	.....
6	12,100	7,350	.705	.595	.585		
	100	*100*	*100*	*100*	*100*	*100*	*100*
10	11,650	7,200	.674	.578	.565		
	96	*98*	*96*	*97*	*97*	*97*	*97*
20	10,700	6,800	.624	.534	.523		
	88	*93*	*89*	*90*	*90*	*90*	*90*
30	10,100	6,500	.590	.508	.496		
	84	*89*	*84*	*86*	*85*	*85*	*86*
40	9,500	6,300	.560	.491	.472		
	79	*86*	*80*	*83*	*81*	*81*	82
50	9,000	6,150	.539	.476	.455		
	75	*83*	*77*	*80*	*78*	*78*	*79*
60	8,600	6,050	.528	.470	.454		
	71	*82*	*75*	*79*	*78*	*77*	*76*

NOTE.—Relative values are indicated by italic figures.

In any one tree the wood is lighter and weaker as we pass from the base to the top. This is true of every tree and of all four species. The decrease in weight and strength is most pronounced in the first 20 feet from the stump and grows smaller upward. (See fig. 1.)

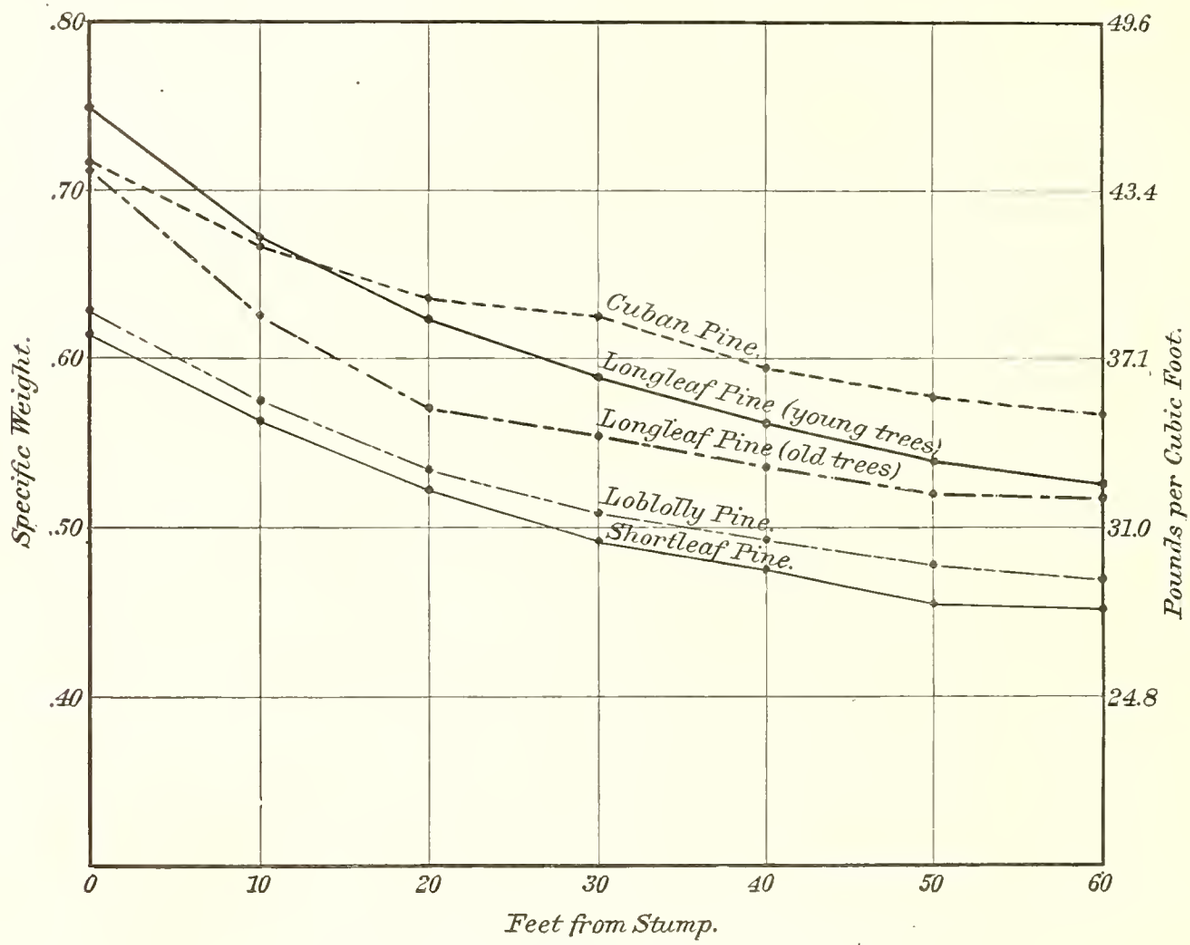

FIG. 1.—Diagram showing variation of weight with height of tree.

This great difference in weight and strength between butt and top finds explanation in the relative width of the summerwood. Since the specific weight of the dark summerwood band in each ring is in thrifty growth from 0.90 to 1, while that of the springwood is only about 0.40, the relative amount of summerwood furnishes altogether the most delicate and accurate measure of these differences of weight as well as strength, and hence is the surest criterion for ocular inspection of quality, especially since this relation is free from the disturbing influence of both resin and moisture contents of the wood, so conspicuous in weight determinations.

The following figures show the distribution of the summerwood in a single tree of Longleaf Pine, as an example of this relation:

	In the 10 rings next to the bark.	In the 10 rings Nos. 100 to 110 from bark.	Average for entire disk.	Specific weight.
	Per cent.	*Per cent.*	*Per cent.*	
At the stump	37	52	50	0.73
32 feet from stump	25	38	33	.59
87 feet from stump	15	37	26	.55

Logs from the top can usually be recognized by the larger percentage of sapwood and the smaller proportion and more regular outlines of the bands of summerwood, which are more or less wavy in the butt logs.

Both weight and strength vary in the different parts of the same cross section from center to periphery, and though the variations appear frequently irregular in single individuals, a definite law of relation is nevertheless discernible in large averages, and once determined is readily observable in every tree.

A separate inquiry, avoiding the many variables which enter into the mechanical tests, permits the following deductions for the wood of these pines, and especially for Longleaf; the data referring to weight, but by inference also to strength:

1. The variation is greatest in the butt log (the heaviest part) and least in the top logs.

2. The variation in weight, hence also in strength, from center to periphery depends on the rate of growth, the heavier, stronger wood being formed during the period of most rapid growth, lighter and weaker wood in old age.

3. Aberrations from the normal growth, due to unusual seasons and other disturbing causes, cloud the uniformity of the law of variation, thus occasionally leading to the formation of heavier, broad-ringed wood in old, and lighter narrow-ringed wood in young trees.

4. Slow-growing trees (with narrow rings) do not make less heavy, nor heavier wood than thriftily grown trees (with wide rings) of the same age. (See fig. 2.)

EFFECT OF AGE.

The interior of the butt log, representing the young sapling of less than fifteen or twenty years of age, and the central portion of all logs containing the pith and two to five rings adjoining, is always light and weak.

The heaviest wood in Longleaf and Cuban Pine is formed between the ages of fifteen and one hundred and twenty years, with a specific weight of over 0.60 and a maximum of 0.66 to 0.68, between the ages of forty and sixty years. The wood formed at the age of about one hundred years will have a specific weight of 0.62 to 0.63, which is also the average weight for the entire wood of old trees; the wood formed after this age is lighter but does not fall below 0.50 up to the two hundredth year; the strength varies in the same ratio.

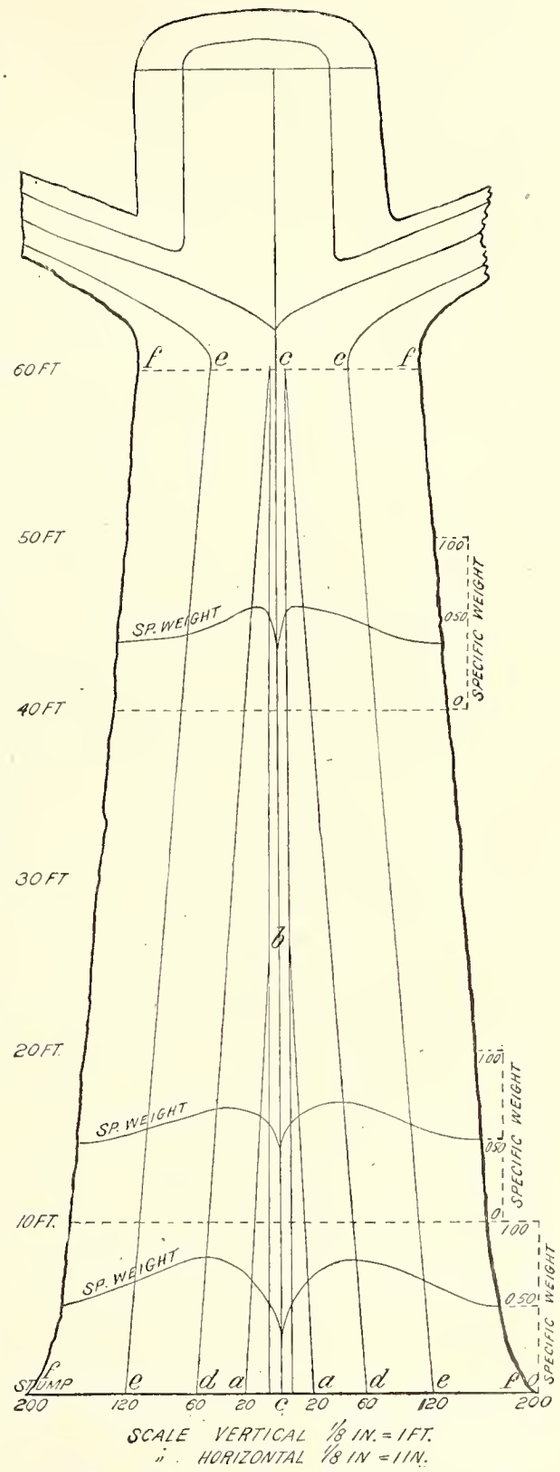

FIG. 2.—Schematic section through stem of Longleaf Pine, showing variation of specific weight with height, diameter, and age at twenty (*aba*), sixty (*dcd*), one hundred and twenty (*eece*), and two hundred (*ffff*) years.

In the shorter-lived Loblolly and Shortleaf the period for the formation of the heaviest wood is between the ages of fifteen and eighty, the average weight being then over 0.50, with a maximum of 0.57 at the age of thirty to forty. The average weight for old trees (0.51 to 0.52) lies about the seventy-fifth year, the weight then falling off to about 0.45 at the age of one hundred and forty, and continuing to decrease to below 0.38, as the trees grow older.

That these statements refer only to the clear portions of each log, and are variably affected at each whorl of knots (every 10 to 30 inches) according to their size, and also by the variable amounts of resin (up to 20 per cent of the dry weight), must be self-evident.

Sapwood is not necessarily weaker than heartwood, only usually the sapwood of the large-sized trees we are now using is represented by the narrow-ringed outer part, which was formed during the old-age period of growth, when naturally lighter and weaker wood is made; but the wood formed during the more thrifty diameter growth of the first eighty to one hundred years—sapwood at the time, changed into heartwood later—was even as sapwood the heaviest and strongest.

RANGE OF VALUES FOR WEIGHT AND STRENGTH.

Although the range of values for the individual tree of any given species varies from butt to top, and from center to periphery by 15 to 25 per cent, and occasionally more, the deviation from average values from one individual to another is not usually as great as has been believed; thus, of 56 trees of Longleaf Pine, 42 trees varied in their average strength by less than 10 per cent from the average of all 56.

The following table of weight (which is a direct and fair indication of strength), representing all the wood of the stem and excluding knots and other defects, gives a more perfect idea of the range of these values:

Range of specific weight with age (kiln-dried wood).

[To avoid fractions the values are multiplied by 100.]

	Cuban.	Longleaf.	Loblolly.	Shortleaf.
Number of trees involved	24	96	60	56
Trees over two hundred years old	61	57	.....	.....
Trees one hundred and fifty to two hundred years old	63	59	50	.....
Trees one hundred to one hundred and fifty years old	.....	60.5	53	51
Trees fifty to one hundred years old	61	62	53.4	55
Trees twenty-five to fifty years old	55	61	53	57
Trees under twenty-five years old	51	55	48	53

Though occasionally some very exceptional trees occur, especially in Loblolly and Shortleaf, the range on the whole is generally within remarkably narrow limits, as appears from the following table:

Range of specific weight in trees of the same age approximately; averages for whole trees.

[Specific gravity multiplied by 100 to avoid fractions.]

Name.	Number of trees.	Age, years.	Single trees.												Average.
Cuban Pine	4	150–200	56	68	62	65	.....	.....	.....	.....	.....	.....	.....	.....	62.5
	5	50–100	60	58	60	59	67	.....	.....	.....	.....	.....	.....	.....	60.9
Longleaf Pine	13	100–150	59	66	57	62	66	58	59	57	57	66	59	62	57	60.5
Loblolly Pine	10	125–150	51	51	53	51	55	53	54	55	55	52	.....	.....	.....	52.8
Shortleaf Pine	12	100–150	45	47	53	47	50	51	55	55	53	51	50	53	.....	50.8

From this table it would appear that single individuals of one species would approximate single individuals of another species so closely that the weight distinction seems to fail, but in large numbers, for instance carloads of material, the averages above given will prevail.

INFLUENCE OF LOCALITY.

In both the Cuban and Longleaf Pine the locality where grown appears to have but little influence on weight or strength, and there is no reason to believe that the Longleaf Pine from one State is better than that from any other, since such variations as are claimed can be found on any 40-acre lot of timber in any State. But with Loblolly, and still more with Shortleaf, this seems not to be the case. Being widely distributed over many localities different in soil and climate, the growth of the Shortleaf Pine seems materially influenced by location. The wood from the Southern Coast and Gulf region and even Arkansas is generally heavier than the wood from localities farther north. Very light and fine-grained wood is seldom met near the southern limit of the range, while it is almost the rule in Missouri, where forms resembling the Norway Pine are by no means rare. The Loblolly, occupying both wet and dry soils, varies accordingly.

INFLUENCE OF MOISTURE.

This influence is among the most important, hence all tests have been made with due regard to moisture contents. Seasoned wood is stronger than green and moist wood; the difference between green and seasoned wood may amount to 50 and even 100 per cent. The influence of seasoning consists in (1) bringing by means of shrinkage about 10 per cent more fibers into the same square inch of cross section than are contained in the wet wood; (2) shrinking the cell wall itself by about 50 per cent of its cross section and thus hardening it, just as a cowskin becomes thinner and harder by drying.

In the following tables and diagram this is fully illustrated; the values presented in these tables and diagrams are based on large numbers of tests and are fairly safe for ordinary use. They still require further revision, since the relations to density, etc., have had to be neglected in this study.

Influence of moisture on strength.

	Per cent of moisture.	Average of all valid tests.				Relative values.				
		Cuban.	Long-leaf.	Lob-lolly.	Short-leaf.	Cuban.	Long-leaf.	Lob-lolly.	Short-leaf.	Aver-age.
Bending strength:										
Green	33+	8,450	7,660	7,370	6,900	100	100	100	100	100
Half dry	20	10,050	8,900	8,650	8,170	118	116	117	118	117
Yard dry	15	11,950	10,900	10,100	9,230	142	142	138	134	139
Room dry	10	15,300	14,000	12,400	11,000	181	182	168	160	173
Crushing endwise:										
Green	33+	5,000	4,450	4,170	4,160	100	100	100	100	100
Half dry	20	6,600	5,450	5,350	5,100	132	122	128	122	126
Yard dry	15	7,850	6,850	6,500	5,900	157	154	156	142	152
Room dry	10	9,200	9,200	8,650	7,000	184	206	206	168	191
Mean of both bending and crushing strength:										
Green	33+					100	100	100	100	100
Half dry	20					125	119	122	120	122
Yard dry	15					149	148	147	138	146
Room dry	10					182	194	187	164	182

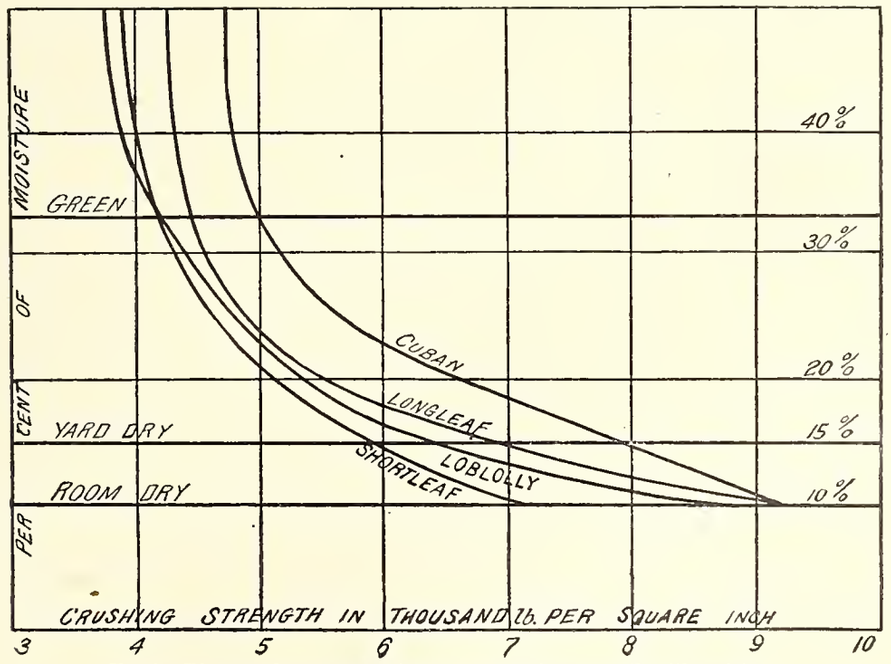

FIG. 3.—Diagram showing variation of compression strength with moisture.

It will be observed that the strength increases by about 50 per cent in ordinary good yard seasoning, and that it can be increased about 30 per cent more by complete seasoning in kiln or house.

Large timbers require several years before even the yard-seasoned condition is attained, but 2-inch and lighter material is generally not used with more than 15 per cent of moisture.

WEIGHT AND MOISTURE.

So far the weight of only the kiln-dry wood has been considered. In fresh as well as all yard and air dried material there is contained a variable amount of water. The amount of water contained in fresh wood of these pines forms more than half the weight of the fresh sapwood, and about one-fifth to one-fourth of the heartwood. In yard-dry wood it falls to about 12 to 18 per cent, while in wood kept in well-ventilated, and especially in heated rooms it is about 5 to 10 per cent, varying with size of piece, part of tree, species, temperature, and humidity of air. Heated to 150° F. (65° C.), the wood loses all but about 1½ to 2 per cent of its moisture, and if the temperature is raised to 175° F. there remains less than 1 per cent, the wood dried at 212° F. being assumed to be (though it is not really) perfectly dry. Of course, large pieces are in practice never left long enough exposed to become truly kiln dry, though in factories this state is often approached.

As long as the water in the wood amounts to about 30 per cent or more of the dry weight of the wood there is no shrinkage[1] (the water coming from the cell lumen), and the density or specific gravity changes simply in direct proportion to the loss of water. When the moisture per cent falls below about 30, the water comes from the cell wall, and the loss of water and weight is accompanied by a loss of volume, so that both factors of the fraction

$$\text{Specific gravity} = \frac{\text{weight}}{\text{volume}}$$

are affected, and the change in the specific gravity no longer is simply proportional to the loss of water or weight. The loss of weight and volume, however, being unequal and disproportionate, a marked reduction of the specific gravity takes place, amounting in these pines to about 8 to 10 per cent of the specific weight of the dry wood.

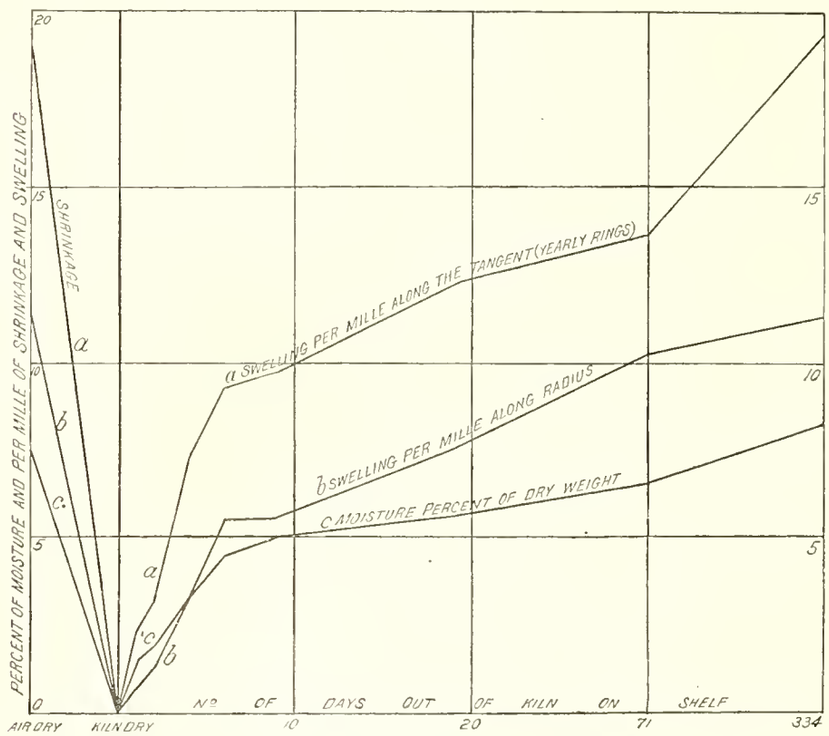

FIG. 4.—Diagram showing loss of water in kiln drying and reabsorption in air, shrinking and swelling.

SHRINKAGE.

The behavior of the wood of the Southern pines in shrinkage does not differ materially. Generally the heavier wood shrinks the most, and sapwood shrinks about one-fourth more than heartwood of the same specific weight. Very resinous pieces ("light wood") shrink much less than other wood. In keeping with these general facts, the shrinkage of the wood of the upper logs is usually 15 to 20 per cent less than that of the butt pieces and the shrinkage of the heavy heartwood of old trees is greater than that of the lighter peripheral parts of the same, while the shrinkage of the heavy wood of saplings is greatest of all. On the whole, the wood of these pines shrinks about 10 per cent in its volume—3 to 4 per cent along the radius, and 6 to 7 per cent along the tangent or along the yearly rings.

After leaving the kiln the wood at once begins to absorb moisture and to swell. In an experiment with short pieces of loblolly and shortleaf, representing ordinary flooring or siding

[1] In ordinary lumber and all large size material the exterior parts commonly dry so much sooner than the bulk of the stick that checking often occurs though the moisture per cent of the whole stick is still far above 30.

sizes, these regained more than half the water and underwent over half the total swelling during the first ten days after leaving the kiln (see fig. 4). Even in this less than air-dry wood the changes in weight far excel the changes in volume (sum of radial and tangential swelling), and, therefore, the specific gravity even at this low per cent of moisture was decreased by drying and increased by subsequent absorption of moisture. Immersion and, still more readily, boiling cause the wood to return to its original size, but temperatures even above the boiling point do not prevent the wood from "working," or shrinking and swelling.

In fig. 4 are represented the results of experiments on the rate of loss of water in the dry kiln and the reabsorption of water in the air. The wood used was of Loblolly and Shortleaf Pine kept on a shelf in an ordinary room before and after kiln drying. The measurements were made with caliper.

EFFECT OF "BOXING," OR "BLEEDING."

"Bleeding" pine trees for their resin, to which only the Longleaf and Cuban Pine are subjected, has generally been regarded as injurious to the timber. Both durability and strength, it was claimed, were impaired by this process, and in the specifications of many architects and large consumers, such as railway companies, "bled" timber was excluded. Since the utilization of resin is one of the leading industries of the South, and since the process affects several millions of dollars' worth of timber every year, a special investigation involving mechanical tests, physical and chemical analyses of the wood of bled and unbled trees from the same locality were carried out by this division. The results prove conclusively (1) that bled timber is as strong as unbled if of the same weight; (2) that the weight and shrinkage of the wood is not affected by bleeding; (3) that bled trees contain practically neither more nor less resin than unbled trees, the loss of resin referring only to the sapwood, and therefore the durability is not affected by the bleeding process.

The following table shows the remarkable numerical similarity between the average results for three groups of trees, the higher values of the bled material being readily explained by the difference in weight:

Longleaf Pine.	Number of tests.	Specific weight of test pieces.	Bending strength per square inch.	Compression strength per square inch.
		Per cent.	*Pounds.*	*Pounds.*
Unboxed trees	400	0.74	12,358	7,166
Boxed and recently abandoned	390	.79	12,961	7,813
Boxed and abandoned five years	535	.76	12,586	7,575

The amount of resin in the wood varies greatly, and trees growing side by side differ within very wide limits. Sapwood contains but little resin (1 to 4 per cent), even in those trees in which the heartwood contains abundance. In the heartwood the resin forms from 5 to 24 per cent of the dry weight (of which about one-sixth is turpentine), and can not be removed by bleeding, so that its quantity remains unaffected by the process.

Bled timber, then, is as useful for all purposes as unbled.

USE OF THE WOOD.

In its use the wood of all four species is much alike. The coarse-grained, heavy, resinous forms are especially suited for timbers and dimension stuff; while the fine-grained wood, whatever species it may belong to, is used for a great variety of purposes.

At present distinction is but rarely made in the species and in their use; all four species are used much alike, although differentiation is very desirable on account of the difference in quality. Formerly these pines, except for local use, were mostly cut or hewn into timbers, but especially since the use of dry kilns has become general and the simple oil finish has displaced the unsightly painting and "graining" of wood, Southern pine is cut into every form and grade of lumber. Nevertheless, a large proportion of the total cut is still being sawed to order in sizes above 6 by 6 inches and lengths above 20 feet for timbers, for which the Longleaf and Cuban Pine furnish ideal material. The resinous condition of these two pines make them also desirable for railway ties of lasting quality.

Since the custom of painting and graining woodwork has given way to natural grain with oil finish, the wood of these hard pines is becoming very popular for inside finish.

Kiln-drying is successfully practiced with all four species, but especially with the Shortleaf and Loblolly pines which, if not artificially seasoned, are liable to "blue." The wood can be dried without great injury at high temperatures.

RATE OF GROWTH.

The species naturally develop somewhat differently, according to the soil conditions in which they occur. Without going into a detailed discussion, which will be found in the body of this work under each species, a comparison of the rate of growth of the four species, based on a large number of measurements, gave, for average trees and average conditions, the results shown in the accompanying diagrams (figs. 5 to 7), which permit the determination of the rate of growth at different periods of their life.

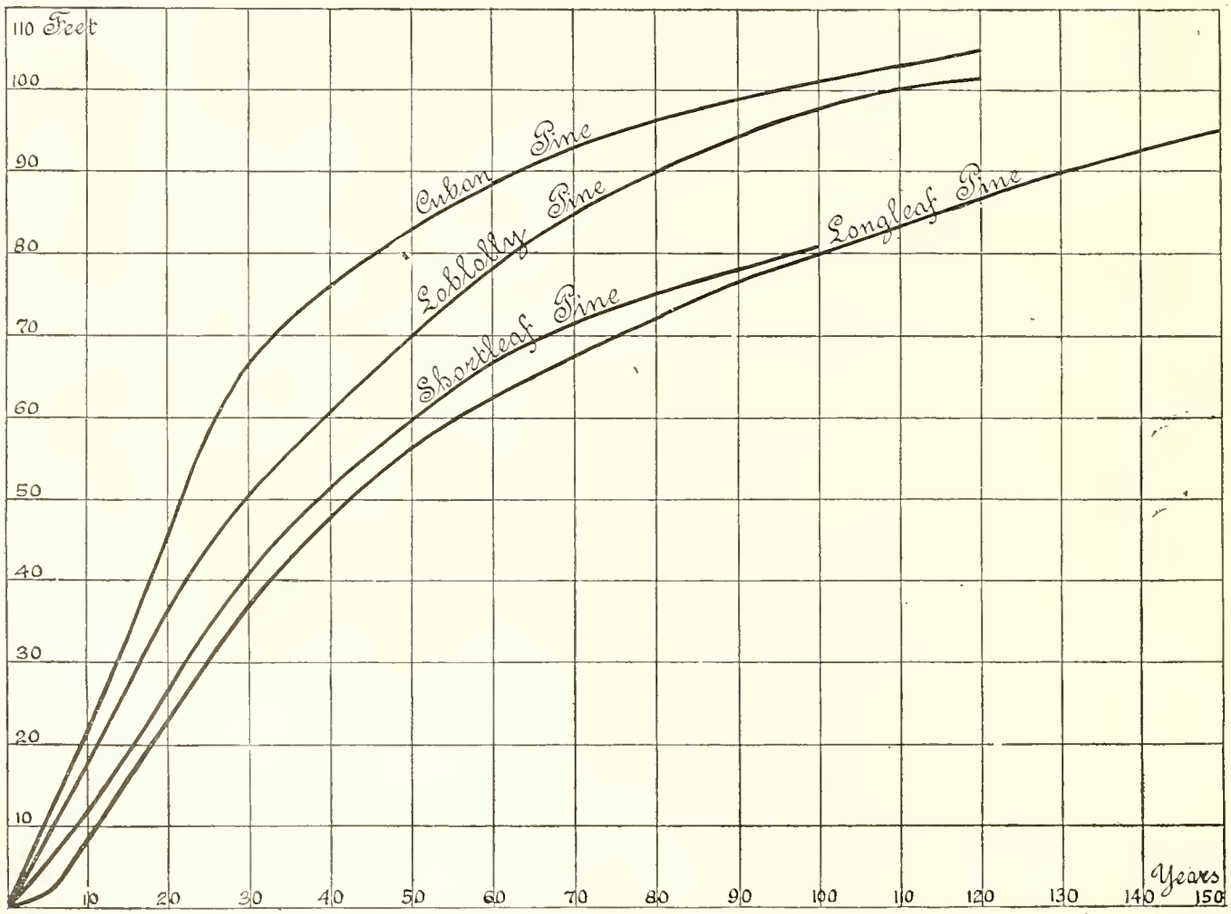

FIG. 5.—Diagram showing comparative progress of height growth in average trees.

From these it appears that the Cuban Pine is by far the most rapid grower, while the Longleaf Pine, which usually grows associated with the former, is the slowest, Loblolly and Shortleaf occupying a position between the two.

The Longleaf shows for the first five to seven years hardly any development in height and begins then to grow rapidly and evenly to the fiftieth or seventieth year, and even after that period, though the rate is somewhat diminished, progresses evenly and steadily, giving to the height curve a smooth and persistent character.

The diameter growth shows the same even and persistent progress from the start, and the volume growth also progresses evenly after the rapid height-growth rate is passed at seventy years.

The Cuban Pine ceases in its maximum rate of height growth at thirty years, starts with its diameter growth at about the rate of the Loblolly, but after the twenty-fifth year leaves the latter

behind for the next twenty-five to thirty years, then proceeds at about the same rate, but persisting longer than the Loblolly. At the age of fifty years the Cuban Pine with 46 cubic feet has made nearly twice the amount of the Loblolly and more than four times that of the Longleaf, but at one hundred years the difference is reduced, being then 115, 90, and 55 cubic feet, respectively, for the three species.

Both Loblolly and Shortleaf Pine reach their maximum growth sooner than the other two species. While these still show a persistently ascending line at one hundred and twenty to one hundred and forty years, the rate of growth in the Loblolly shows a decline after the one hundredth year, and the Shortleaf has done its best by the eightieth year. These facts give indications as to the rotation under which these various species may be managed.

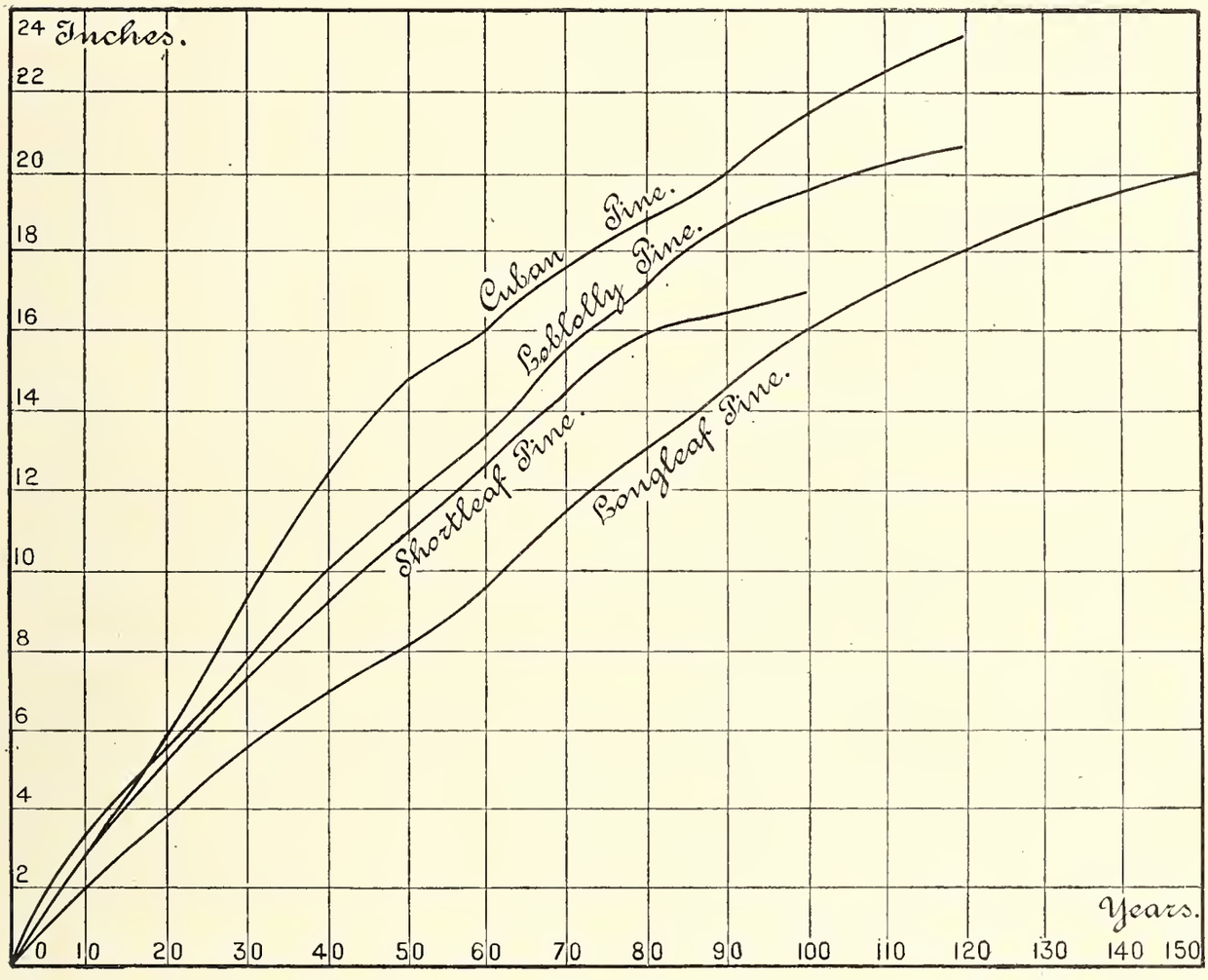

FIG. 6.—Diagram showing comparative progress of diameter growth in average trees.

As stated before, the growth of trees, especially in the virgin forest, is quite variable even for the same species and same soil conditions; an average, therefore, like the one presented in the diagrams, however perfect, could apply only when large numbers are considered. Thus there are fast-growing trees of Longleaf and slow-growing of Cuban or Loblolly Pine. Yet the diagrams will fairly well represent the average growth, with the possible exception of the Cuban Pine, for which the number of measurements was too small to furnish reliable data.

STATISTICS AND CONCLUSIONS.

The greatest difficulty Dr. Mohr has found is in the statistical portions of his work. To determine the amounts of remaining timber supplies of the various species is almost an impossibility without a very elaborate and laborious canvass, which, to be sure, it would appear our duty to

undertake, but for which the means at the disposal of the Division of Forestry have never been sufficient. Even the amount of annual consumption can only be approximated, partly because the species are not always kept separate and partly because information is not always readily given by the operators or shippers.

The statistics for Longleaf Pine can be more nearly approximated, for the majority of the mills engaged in its exploitation cut hardly any other timber; moreover, its geographical limits are more clearly defined, so that even the area of remaining supplies is not entirely beyond our ken.

When it comes to using such statistics for a prognostication as regards available supplies, another difficulty arises in the change of standards of material recognized as marketable and the change of demand or use, and hence consumption, of any of the varieties. But we can now safely assume that the standard of size and quality, which was high when the census figures of 1880 were

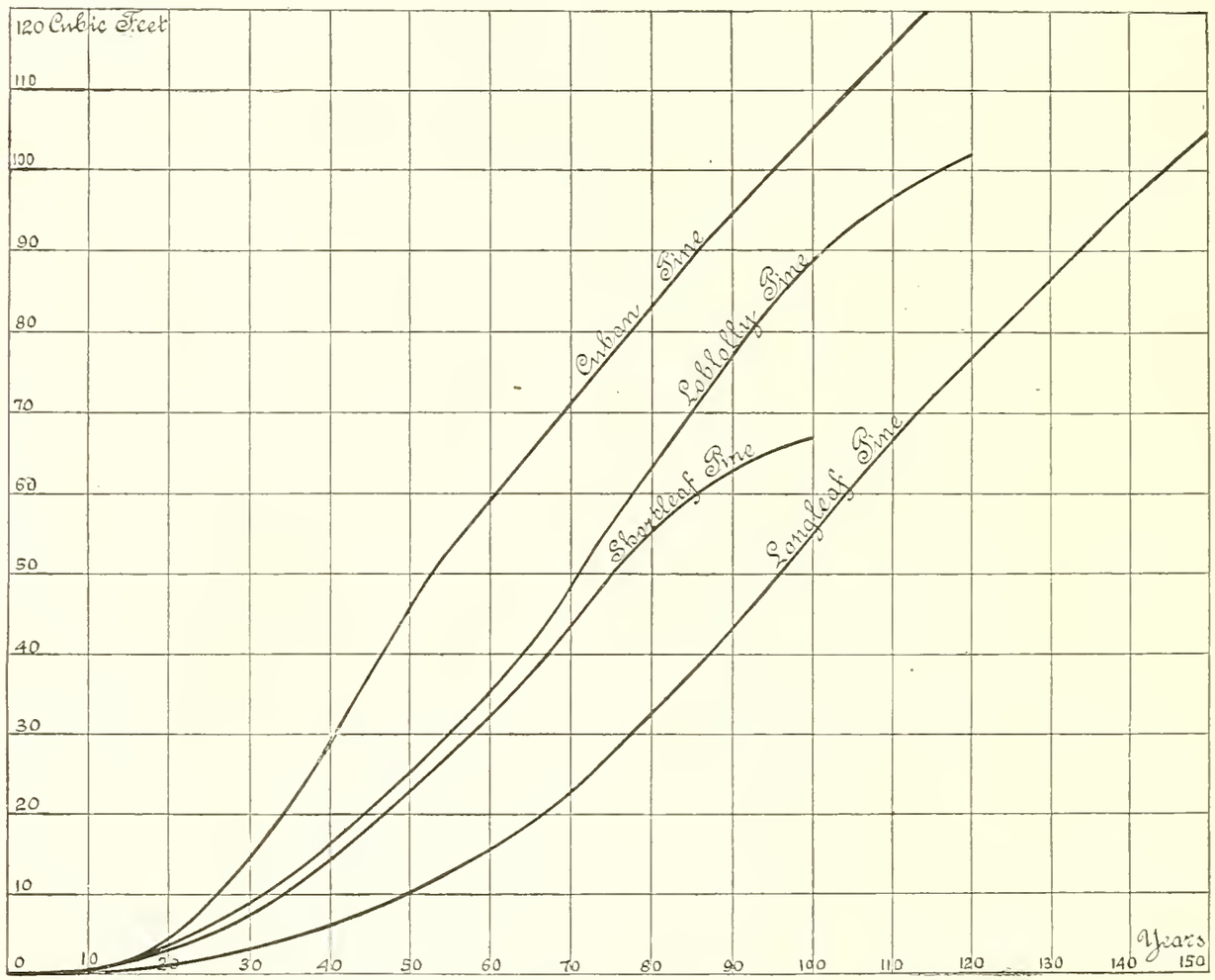

FIG. 7.—Diagram showing comparative progress of volume growth in average trees.

estimated and hence made them appear below the truth, has now sunk nearly to the lowest level, any stick that can be placed on the mill down to 10-inch and 8-inch being fit material. There is also no danger of any reduction in the cut for any reason except a temporary one due to such general business depression as that experienced throughout the last two years. Increase of consumption of Southern timber is bound to follow the imminent exhaustion of the pine supplies of the North. And with the exception of Pacific Coast timbers, which, owing to their great distance, have so far made but little competition in Eastern markets, no new undiscovered timber resource will influence the cut of Southern pine.

Venturing on the basis of the meager data furnished in this publication to make a guess at the probable supply and demand, we may with due reserve state that the amount of pine timber ready for lumber manufacture standing in the South can not be above 250,000,000,000 feet, and

more likely will fall far below 200,000,000,000 feet, while the figure for present and lowest future annual consumption may be approximated at near 7,000,000,000 feet, board measure.[1]

There is nobody who knows or can know the actual condition of supplies, and whoever has an opinion on the subject will have to bring at least as good a basis or a better one for such opinion than the data furnished in the following monographs.

There is no attempt to predict from the foregoing figures the absolute exhaustion of the pine supplies of the South within forty or fifty years, although such a result would appear not unlikely. Competition of other timbers, and substitutes for the use of wood (which, to be sure, never in the history of the world have reduced wood consumption), and especially changes in present methods of exploitation, may lengthen out supplies for a short time; or, if we begin rational forestry now, these forests may be kept a source of continuous supplies, even though reduced.

Those who rely upon the spontaneous natural reproduction of these pines to fill the gaps made in the virgin timber will do well to read the chapters on natural reproduction and the incidental remarks regarding the conditions for renewal and the appearance of the aftergrowth; or, better, tramp through the vast region of culled pine woods and observe what the basis of their reliance is, as the writer of these monographs has done through forty years of his life. If, in addition, they study the chapters on conditions of development, they will realize that the Longleaf Pine is bound to disappear largely even in the regions where it reigned supreme; that the Cuban Pine, no despicable substitute, will take its place in the lower pine belt, if allowed to propagate at all; but on large burnt areas the growth of scrubby oaks and brush will forever exclude this species which eminently needs light. Loblolly and Shortleaf, better fitted for warfare with other species, will do much in their respective habitats to recuperate, except in the mixed forest, where they are culled and the hard woods are left to shade out the aftergrowth; or where the continuous conflagrations have destroyed the mold and aftergrowth and given over the soil to scrubby brushgrowth, which for ages will either prevent the gradual return of the pines or impede their renewal and growth. Considering that the timber on which we now rely and on which we base our standards comes from trees usually from one hundred and fifty to two hundred years or more old, and that none of these pines makes respectable timber in less than from sixty to one hundred and twenty-five years, the necessity of timely attention to their renewal is further emphasized.

The owners of timber land and the operators of mills are the only people who can improve these conditions, and this by a more rational treatment of their property. If they can be made to realize now that what they own and hold as a temporary speculation will, in a short time, when supplies have visibly decreased, become a first-class investment, and, by its revenues, become a greater source of wealth under competent management with a view to reproduction than that which they have derived from it by the mere robbing of the old timber, they might take steps at least against the unnecessary damage done to it by fire and cattle. Permanency and continuity of ownership appear to be the first condition to insure such results, and therefore corporations which are not of an ephemeral character and men of large wealth are most desirable forest owners.

The monographs here presented will, it is hoped, aid in this realization, and the information regarding the conditions of development of the different species will furnish suggestions as to the forest management which, modified according to local conditions and economic considerations, may be employed to secure the perpetuity of the Southern pineries.

B. E. Fernow.

Washington, D. C., *June 5, 1896.*

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[1] The entire region within which these pines occur in merchantable condition comprises about 230,000 square miles or, in round numbers, 147,000,000 acres; for land in farms, etc., 10,000,000 acres must be deducted, and allowing as much as two-thirds of the remainder as representing pine lands (the other to hardwoods), we would have about 90,000,000 acres on which pine may occur. An average growth of 3,000 feet per acre, an extravagant figure when referred to such an area, would make the possible stand, 270,000,000,000 feet, provided it was in virgin condition and not mostly culled or cut.

FIG. 1.—LONGLEAF PINE FOREST IN LOUISIANA FLATS. VIRGIN, SCORCHED BY FIRE AS USUAL.

FIG. 2.—LONGLEAF PINE FOREST AFTER REMOVAL OF MERCHANTABLE TIMBER.

THE LONGLEAF PINE.

(PINUS PALUSTRIS Miller.)

GEOGRAPHICAL DISTRIBUTION.
PRODUCTS AND USES.
BOTANICAL DESCRIPTION.
DESCRIPTION OF WOOD.
PROGRESS OF DEVELOPMENT.
CONDITIONS OF DEVELOPMENT.
FOREST MANAGEMENT.
APPENDIX: THE NAVAL STORE INDUSTRY.

THE LONGLEAF PINE.

(*Pinus palustris* Miller.)

Synonyms: *Pinus palustris* Miller, Gard. Dict. ed. 8, No. 14 (1768).
Pinus lutea Walter, Fl. Car. 237 (1788).
Pinus australis Michaux f., Hist. Arb. Am. i. 64, t. 6 (1803).
Pinus serotina Hort. Cf. Bon Jard. 976 (1837) ex Antoine, Conif. 23 (1840–'47), not Michx. (1803).
Pinus Palmiensis Fr. Gard. ex Gordon, Pinetum ed. 1, Suppl. 63 (1862).
Pinus Palmieri Manetti ex Gord., l. c. (1862).

LOCAL OR COMMON NAMES.

Longleaved Pine (Del., N. C., S. C., Ga., Ala., Fla., Miss., La., Tex.).
Southern Pine (N. C., Ala., Miss., La.).
Yellow Pine (Del., N. C., S. C., Ala., Fla., La., Tex.).
Turpentine Pine (N. C.).
Rosemary Pine (N. C.).
Brown Pine (Tenn.).
Hard Pine (Ala., Miss., La.).
Georgia Pine (Del.).
Fat Pine (Southern States).
Southern Yellow Pine (general).
Southern Hard Pine (general).
Southern Heart Pine (general).
Southern Pitch Pine (general).
Heart Pine (N. C. and Southern Atlantic region).
Pitch Pine (Atlantic region).
Longleaved Yellow Pine (Atlantic region.)
Longleaved Pitch Pine (Atlantic region).
Long-straw Pine (Atlantic region).
North Carolina Pitch Pine (Va., N. C.).
Georgia Yellow Pine (Atlantic region).
Georgia Pine (general).
Georgia Heart Pine (general).
Georgia Longleaved Pine (Atlantic region).
Georgia Pitch Pine (Atlantic region).
Florida Yellow Pine (Atlantic region).
Florida Pine (Atlantic region).
Florida Longleaved Pine (Atlantic region).
Texas Yellow Pine (Atlantic region).
Texas Longleaved Pine (Atlantic region).

THE LONGLEAF PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

The Longleaf Pine is the tree of widest distribution and of greatest commercial importance in the Southern Atlantic forest region of eastern North America, covering, with scarcely any interruption, areas to be measured by tens of thousands of square miles and furnishing useful material.

The timber wealth of the forests of Longleaf Pine, much of which is still untouched, has given rise to industries which involve the outlay of vast capital and an extensive employment of labor, thus closely affecting the prosperity of a large part of the Southern States as well as the industrial and commercial interests of the whole country.

With the impending exhaustion of the pine forests of the North, the lumber interests of the country are steadily tending to center in the South, attracted chiefly by the forests of Longleaf Pine.

The Old World, which has heretofore depended almost entirely upon the pine forests of Canada and of the Northern United States for timber for heavy construction, is already importing a large amount of hewn and sawn square timber and of lumber from the Southern pine forests. Most of the lumber used for ordinary building purposes in the West Indies, on the coast of Mexico, and in many of the States of South America is furnished by the mills situated in the Longleaf Pine region. The unprecedented increase, during the last quarter of a century, of the population in the timberless regions of the far West, as well as in the country at large, enormously augment the drafts made upon these forests, threatening their eventual exhaustion and ultimate destruction unless measures are taken by which these supplies may be perpetuated. The solution of the difficult problem of devising such measures can come only as a result of a study of the life history of the Longleaf Pine, of the conditions required for its growth and best development, of the laws regulating its distribution, and of the possibilities for its natural or artificial restoration.

HISTORICAL.

The economic importance of the Longleaf Pine was well recognized in early times. Bartram,[1] in the year 1777, in his wanderings along the western shore of Mobile Bay, had his attention attracted by three very large iron pots, or kettles, each with a capacity of several hundred gallons, near the remains of an old fort or settlement, which he was informed were used for the purpose of boiling down the tar to pitch, there being vast forests of pine in the vicinity of this place. "In Carolina," this writer proceeds, "the inhabitants pursue a different method. When they are going to make pitch they dig large holes in the ground, which they line with a thick coat of good clay, into which they conduct a sufficient quantity of tar and set it on fire, suffering it to burn and evaporate for some time, in order to convert it into pitch, and when cool, put it into barrels until they have consumed all the tar and made a sufficient quantity of pitch for their purposes."

Humphrey Marshall, one of the earliest writers on North American forest trees,[2] mentions the Longleaf Pine under the name of the "largest three-leaved marsh pine, as accounted equal to any for its resinous products." In North Carolina crude resin, tar, and pitch figured as important and valuable exports during the later colonial times. During the period from 1766 to 1769, $130,000

[1] Bartram's Travels through North and South Carolina. Philadelphia, 1790.

[2] Humphrey Marshall: Arbustum Americanum, or the American Grove. Philadelphia, 1785.

worth of these stores were exported yearly; among them were 88,111 barrels of crude resin, valued at $11,244.85. F. A. Michaux, in his travels west of the Alleghany Mountains, speaking of the low country of the Carolinas, says:[1] "Seven-tenths is covered with pine of one species, *Pinus palustris*, which, as the soil is drier and lighter, grows loftier; these pines, encumbered with very few branches and which split even, are preferred to other trees for building fences on plantations." In his subsequent work Michaux gives for the first time an accurate and detailed account of the products of this tree and their industrial and commercial importance, as well as of its distribution and a description of its specific characters.[2]

NOTE.—In sketching the topographical features of those regions of the Longleaf Pine forests, which did not come under the personal observation of the writer, the physiographical descriptions of the Cotton States on the Atlantic Coast and the Gulf region published in Professor Hilgard's report on cotton production in the fifth and sixth volumes of the Census of 1880 were freely drawn upon, and these reports were also consulted, together with Table VII in the statistics published in the census report on productions of agriculture in the computation of forest areas.

In the statements of the amount of Longleaf Pine standing in the several States in 1880 and of the cut during the same year, the figures given in Prof. Charles S. Sargent's report, Vol. IX of the Tenth Census, were introduced, and for those which relate to Alabama and Mississippi the writer is mostly responsible. No efforts have been spared to arrive at a correct estimate of the total amount and value of square timber, lumber, and naval stores produced during the decade ending with the year 1890 and during the business year 1893, in order to place in a proper light the economic importance of the tree and its bearings upon the industrial and commercial interests of the country, and also to show the rapid increase of the industries depending directly upon the resources of this tree. The statements given are, however, of necessity only approximations falling below the limits of truth, as it was impossible to ascertain with any degree of accuracy the quantities entering into home consumption. Thus a factor of no little importance had to be neglected.

The thanks of the writer are due to the gentlemen who kindly assisted him by their prompt replies to his inquiries in his search for information, and who in other ways have afforded him aid.

GEOGRAPHICAL DISTRIBUTION.

The Longleaf Pine is principally confined to a belt about 125 miles in width in the lower parts of the Southern States which border upon the Atlantic and the Gulf shores. The northern limit of the tree is found on the coast near the southern boundary of Virginia below Norfolk, north latitude 36° 30′. From here the forests of the Longleaf Pine extend southward along the coast region to Cape Canaveral, across the peninsula of Florida a short distance south of Tampa Bay, westward along the Gulf Coast to the uplands which border upon the alluvial deposits of the Mississippi. West of that river forests of this species continue to the Trinity River in Texas; in that State its northern limit is found to reach hardly 32° north latitude, while in Louisiana and Mississippi it extends hardly more than half a degree farther north, and in Alabama under 34° 30′ the tree is found to ascend the extreme southern spurs of the Appalachian chain to an altitude of between 900 and 1,000 feet. Thus the area of the distribution of the Longleaf Pine extends from 76° to 96° west longitude and from 28° 30′ to 36° 30′ north latitude. (See Pl. III.)

With reference to the distribution of this species as depending upon geological formation, it may be said that its forests are chiefly confined to the sandy and gravelly deposits designated by Professor Hilgard as the orange sand, or Lafayette strata of Post-Tertiary formation, which of late is regarded as the most recent member of the Tertiary formation. These siliceous sands and pebbles, which to such vast extent cover the lower part of the Southern States and form also more or less the covering of the surface throughout the older Tertiary region, offer the physical conditions most suitable to the growth of this tree.

CHARACTERISTICS OF DISTRIBUTION IN DIFFERENT REGIONS.

This great maritime pine belt east of the Mississippi River presents such differences in topographical features and such diversity of physical and mechanical conditions of the soil as to permit a distinction of three divisions going from the coast to the interior:

1. The coastal plain, or low pine barrens within the tide-water region, extends from the seashore inland for a distance of from 10 to 30 miles and over. The forests of the Longleaf Pine which

[1] Travels West of the Alleghanies, by F. A. Michaux. Paris, 1803.

[2] F. A. Michaux, Histoire des Arbres forestiers de l'Amer., Sept. Paris, 1811. Philadelphia Edition, 1852, Vol. III, p. 106 et seq.

LEGEND.

- BOUNDARY LINES OF BOTANICAL DISTRIBUTION.
- BOUNDARY LINES OF REGIONAL ECONOMIC DISTRIBUTION.
- BOUNDARY LINE OF REGION OF MIXED GROWTH.
- NORTHERN LIMIT OF PINUS CUBENSIS.
- AREAS ON WHICH THE SPECIES OCCURS SCATTERED.
- I — YIELD 1000 TO 2000 FEET B. M. PER ACRE. ALMOST OR COMPLETEY EXHAUSTED.
- II — YIELO 2000 TO 4000 FEET B M. PER ACRE.
- III — YIELD 4000 TO 6000 FEET B. M. AND OVER PER ACRE.

MAP

SHOWING DISTRIBUTION OF

PINUS PALUSTRIS (LONGLEAF PINE)

AND

PINUS CUBENSIS (CUBAN PINE)

Prepared by CHAS. MOHR,

Agent.

Scale

100 0 100 200 300 400 500 600 Miles

A. Hoen & Co. Lith. Baltimore

Plate III.

occupy the poorly drained grassy flats of the plain are very open, intersected by numerous inlets of the sea and by brackish marshes. They are also interrupted by swamps densely covered with Cypress White Cedar, White and Red Bay, Water Oak, Live Oak, Magnolia, Tupelo Gum, and Black Gum and again by grassy savannas of greater or less extent. On the higher level, or what might be called the first terrace, with its better drained and more loamy soil, the Longleaf Pine once prevailed, but almost everywhere in the coastal plain the original timber has been removed by man and replaced by the Loblolly Pine and the Cuban Pine.

2. The rolling pine lands, pine hills, or pine barrens proper are the true home of the Long-Leaf Pine. On the Atlantic Coast these uplands rise to hills over 600 feet in height, while in the Gulf region they form broad, gentle undulations rarely exceeding an elevation of 300 feet. Thus spreading out in extensive table-lands, these hills are covered exclusively with the forests of this tree for many hundreds of square miles without interruption. Here it reigns supreme. The monotony of the pine forests on these table-lands is unbroken.

3. The upper division, or region of mixed growth. With the appearance of the strata of the Tertiary formation in the upper part of the pine belt, the pure forests of the Longleaf Pine are confined to the ridges capped by the drifted sands and pebbles and to the rocky heights of siliceous chert, alternating with open woods of oak (principally Post Oak), which occupy the richer lands of the calcareous loams and marls. However, where these loams and marls, rich in plant food, mingle with the drifted soils, we find again the Longleaf Pine, but associated with broad-leaved trees and with the Loblolly and Shortleaf Pine. Here the Longleaf Pine attains a larger size and the number of trees of maximum growth per acre is found almost double that on the lower division.

TIMBER REGIONS—SUPPLY AND PRODUCTION.

The forests of Longleaf Pine can be conveniently discussed by referring to the following geographical and limited areas:

The Atlantic pine region;
The maritime pine belt of the eastern Gulf States;
The central pine belt of Alabama;
The forests of Longleaf Pine of north Alabama (Coosa basin, etc.);
The regions of Longleaf Pine west of the Mississippi River.

THE ATLANTIC PINE REGION.

The Atlantic pine region in its extent from the southern frontier of eastern Virginia to the peninsula of Florida embraces the oldest and most populous States of the Longleaf Pine district, and here the forests have suffered most severely by lumbering, the production of naval stores, and clearing for purposes of agriculture.

Virginia.—The forests of the Longleaf Pine on the southeastern border of Virginia have almost entirely disappeared, and are, to a great extent, replaced by a second growth of Loblolly Pine.

North Carolina.—In North Carolina the area over which this tree once prevailed may be estimated at from 14,000 to 15,000 square miles, leaving out of calculation the coastal plain with its extensive swamps, wide estuaries, and numerous inlets. From the northern frontier of the State southward, some distance beyond the Neuse River, in the agricultural district, the forest growth on the level or but slightly undulating pine land is of a mixed character, the Longleaf species being largely superseded by the Loblolly Pine, together with widely scattered Shortleaf Pine and deciduous trees—White Oak, Red Oak, Post Oak, Black Oak, and more rarely Mockernut and Pignut Hickory, and Dogwood. In this section the lumbering interests are chiefly dependent upon the Loblolly Pine (*Pinus taeda*), better known to the inhabitants as the Shortstraw, or Shortleaf Pine (not to be confounded with the true Shortleaf Pine). The forests of Longleaf Pine begin at Bogue Inlet, extend along the coast to the southern boundary of the State, and inland for a distance varying between 50 and 135 miles.

The highly siliceous soil of these pine barrens offers but little inducement for its cultivation; the inhabitants, therefore, from the earliest time of the settlement of the State have chiefly been engaged in pursuits based on the products of the pine forests. Here the production of naval

stores was first carried on; rosin, tar, and pitch figured in early colonial times among the most important articles of export. In consequence, the forests of the Longleaf Pine have been, with but slight exceptions, invaded by turpentine orcharding, and at the present time by far the greater part of the timber standing has been tapped for its resin. The forests of the Longleaf Pine in this State cover the largest area in the basin of Cape Fear River, with Wilmington the main port of export for their products. The export from this port had increased from 21,000,000 feet of lumber in 1880, to nearly 40,000,000 annually, on the average, for the years 1887 to 1891.

The forests of the Longleaf Pine on the banks of the Neuse River, in Johnston County and in Wayne County, are almost exhausted; about 40 to 50 per cent of the timber sawn at Goldsboro and Dover is Longleaf Pine timber from that section, and is invariably bled. A considerable number of the trees from the old turpentine orchards, with the excoriated surface of the trunk ("chip") over 25 feet in length and bled again after a lapse of years, show that they have been worked for their resin for twenty to twenty-four years in succession, and after a longer or shorter period of rest have been subjected to the same treatment continually for the same number of years. Such old martyrs of the turpentine orchard are unfit for lumber, but, impregnated as they are with resin, are used for piling and for posts of great durability.

East of the Neuse River, from the upper part of Johnston County, in an almost southern direction to Newbern, no Longleaf Pine has been observed. Single trees of the Shortleaf Pine (*Pinus echinata*) have been found scattered among the growth of deciduous trees which cover the ridges between the Trent and Neuse rivers, and isolated tracts of a few acres of the Longleaf species are met with in the low flats of the same section, which were in 1894 almost exclusively occupied by the Loblolly Pine.

As reported for the Tenth Census, the amount of Longleaf Pine standing in North Carolina at the beginning of the census year was estimated to be 5,229,000,000 feet, board measure. No reliable information could be obtained as to the amount of timber cut since 1880, consequently no data are at hand from which to compute the amount now standing. The cut for the year 1880 is given in the census report at 108,400,000 feet, board measure. In 1890, eighteen mills were enumerated as engaged in sawing exclusively Longleaf Pine timber, almost all situated in the basin of Cape Fear River, with a daily aggregate capacity of 475,000 feet, board measure. Such capacity would point to an annual cut of at least 65,000,000 feet, board measure.

Statement of the shipments of naval stores from Wilmington, N. C.

[From J. L. Cantwell, secretary Wilmington Produce Exchange.]

Year.	Spirits of turpentine.	Rosin.	Crude resin or turpentine.	Tar.
	Casks.	*Barrels.*	*Barrels.*	*Barrels.*
1880	125,585	663,967	.....	.....
1881	90,000	450,000	2,323	.....
1882	88,376	425,925	3,188	56,113
1883	87,050	483,432	31,966	75,544
1884	78,978	434,376	45,966	85,230
1885	71,145	310,808	35,290	70,530
1886	63,580	324,942	25,662	61,195
1887	71,912	381,335	21,572	68,143
1888	63,437	246,516	18,171	63,163
1889	69,668	351,827	19,082	68,856
1890	70,289	385,523	.....	71,949
1891	67,480	349,500	16,900	63,700
1892	59,283	287,200	15,500	67,900
1893	58,336	274,800	15,500	70,500
1894	46,036	189,900	9,900	45,500
Total	1,111,155	5,560,051	261,026	868,323
Value	$19,000,000	$10,000,000	$391,500	$1,100,000

Total value, $30,500,000.

Statement of shipments of lumber to foreign and domestic ports from Wilmington, N. C.

Year.	Feet, board measure.	Year.	Feet, board measure.	Year.	Feet, board measure.
1880	21,000,000	1885	36,000,000	1890	40,066,000
1881	45,498,480	1886	39,500,000	1891	29,580,160
1882	40,291,146	1887	41,000,000	1892	25,874,331
1883	35,465,000	1888	36,680,000	1893	30,595,930
1884	30,000,000	1889	40,289,000	1894	35,353,412

South Carolina.—The forests of Longleaf Pine in this State follow more closely the coast line, with an extension inland averaging 100 miles. The lower parts of the pine belt, or the Savannah region, is low and flat, rising but slowly above the brackish marshes and alluvial lands bordering the sea. Traversed by eight large rivers with wide estuaries and bordered by extensive swamps of Cypress, Magnolia, Red and White Bay, Laurel Oak, etc., its area has been estimated to be 7,000 square miles, 4,500 square miles of which are occupied by swamp lands, including the grassy marshes on the coast. In the low, perfectly level pine barrens, with a soil of fine, compacted, almost impervious sand, covered with the Saw Palmetto, the Pond Pine, and a stunted growth of the Cuban and Loblolly Pine, the Longleaf Pine is rarely seen, and always of dwarfed growth. In the flat woods bordering the alluvial swamps, heavily timbered with Loblolly and Cuban Pine, the Longleaf Pine makes its appearance more frequently, and finally prevails almost exclusively on the broad, dry, sandy ridges, associated with the Barren or Turkey Oak (*Quercus catesbæi*), stunted Spanish Oak, and Upland Willow Oak (*Quercus cinerea*), trees of smaller size forming the undergrowth. The timber growth on these ridges is rather open and of good quality. As has been observed near Ridgeland, in the counties of Beaufort and Hampton, the forests have to a large extent given way to the plow, and along the railroads they have been destroyed by turpentine orcharding. Upon 1 acre, representing fairly the original timber growth of the forests on these ridges, 48 trees of a diameter of from 12 to 24 inches at breast high, with a height of from 50 to 110 feet, were found. Of these, 4 yielded sticks of clear timber averaging 45 feet in length with mean diameter of 18 inches, equal to 2,000 feet, board measure, of first-class lumber. These trees varied in age from 136 to 145 years; 8 trees yielded sticks of timber free from limbs 40 feet in length with mean diameter of 17 inches, equal to 3,200 feet, board measure, age on the average 140 years; 12 trees yielded 35 feet length of clear timber with mean diameter of 16 inches, equal to 3,600 feet of merchantable lumber, age from 130 to 136 years; 8 trees averaged 12 inches mean diameter, length of timber 30 feet, equal to 950 feet, board measure, age from 110 to 118 years; 4 trees averaged 10 inches mean diameter, length of clear timber 24 feet, wood sappy throughout, yielding 200 feet of lumber, age from 80 to 85 years.

The total yield of merchantable lumber of this acre would be 9,950 feet, board measure, representing the average of the better quality of these timber lands. As in the adjoining States, the forests along the railroad lines for a wide distance have been subjected to turpentine orcharding, and but a small percentage of the timber standing has escaped the ax of the "box" cutter. The receipts of naval stores at Charleston during the ten years from 1880 to 1890 averaged annually 57,570 casks (50 gallons to a cask) of spirits of turpentine and 225,920 barrels of rosin, with the largest receipts in 1880 of 60,000 casks of spirits of turpentine and 259,940 barrels of rosin, and the smallest of 40,253 casks of spirits in 1888, and 170,066 barrels of rosin in 1886.

Tabular statement of the shipments of naval stores at Charleston, S. C., from the beginning of 1880 to the close of the year 1894.

[From the annual statements of the commerce of Charleston, S. C., published in the Charleston Courier.*]

Year.	Spirits of turpentine.	Rosin.	Year.	Spirits of turpentine.	Rosin.
	Casks.	*Barrels.*		*Casks.*	*Barrels.*
1880	60,000	259,940	1889	43,127	149,348
1881	51,386	231,417	1890	49,232	217,865
1882	69,027	258,446	1891	35,414	163,816
1883	65,914	285,446	1892	25,969	127,262
1884	64,207	264,049	1893	22,543	121,624
1885	44,126	218,971	1894	14,415	71,329
1886	40,375	170,066			
1887	52,549	171,154	Total	678,537	2,892,619
1888	40,253	181,886	Value	$11,874,397	$5,206,714

* The annual receipts on the average equal the exports.

The rolling pine hills bordering upon the flat woods, or swamps, reach elevations of 130 to 250 feet above the sea, with a width of from 20 to 40 miles, and, as on the pine ridges of the low pine barrens mentioned before, the upland oaks form the sparse undergrowth in the forests of Longleaf Pine. Nearly one-third of the area (estimated at about 4,500 square miles) has been opened to cultivation. These rolling pine lands rise on their northern borders abruptly to a range of steep hills over 600 feet above sea level, covered with a rather scanty growth of Longleaf

Pine among the Shortleaf Pine and fine upland oaks, the latter largely prevailing. On the south and west these hills merge into an elevated plateau with a loose soil of coarse white sand. Here the Longleaf Pine is found in its full perfection and furnishes timber of excellent quality.[1] About 12 per cent of these pine-clad table-lands are under cultivation, and about 22 per cent of the hills, with their generous red soil, are covered with a mixed growth of pine and oak; both of these divisions cover an area of not less than 4,000 square miles.[2]

The Longleaf Pine timber standing in South Carolina in the census year 1880 was estimated at 5,316,000,000 feet, board measure,[3] with an annual cut of 124,000,000 feet.

In 1890 forty mills sawing exclusively Longleaf Pine timber have been reported[4] with an aggregate daily capacity of about 510,000 feet, taken at the lowest figure. This would indicate for that year a cut of 68,000,000 feet, board measure, which may also be considered the average annual cut for the last fifteen years.

The exports of lumber from Charleston, the chief port, have since the year 1880 steadily increased, the excess in 1890 over the amount in 1880 reaching over 400 per cent, as is exhibited in the following statement:

Statement of lumber exported from Charleston, S. C., to foreign and domestic ports from the beginning of 1880 to the close of 1894.

[Includes considerable Loblolly and Shortleaf Pine.]

Year.	Feet, board measure.	Year.	Feet, board measure.
1879–80	15,437,000	1887–88	45,270,000
1880–81	18,500,000	1888–89	50,532,000
1881–82	43,000,000	1889–90	68,400,000
1882–83	40,000,000	1890–91	61,226,827
1883–84	35,589,000	1891–92	53,286,608
1884–85	30,034,000	1892–93	61,093,344
1885–86	26,800,000	1893–94	69,940,453
1886–87	32,672,000		

Georgia.—The great pine State of the South, which has given to the Longleaf Pine the name of Georgia Pine, by which this lumber is known the world over, embraces the largest of the Atlantic pine forests. At a rough estimate, these cover over 19,000 square miles, including the narrow strip of live-oak lands bordering the seashore. The flat woods and savannas of the coast plain are from 10 to 15 miles wide. They are almost entirely stripped of their growth of Longleaf Pine.

The upland pine forests, the pine barrens proper, or wire-grass region,[5] embrace over 17,000 square miles. This region forms a vast plain, nearly level except on the north, covered exclusively with Longleaf Pine. About 20 per cent of these lands have been cleared for cultivation.

Formerly the principal sites of the lumber industry were Darien, Brunswick, and Savannah The logs were rafted hundreds of miles down the Savannah, the Ogeechee, the Altamaha and its large tributaries, the Oconee and Oemulgee. A limited quantity is carried down the Flint and Chattahoochee rivers to Apalachicola. The railroads, however, supply the mills now to the largest extent.

The forests of these pine uplands are in quality, and originally in quantity, of their timber resources equal to any found east of the Mississippi River. The soil is a loose sand, underlaid by a more or less sandy buff-colored or reddish loam. The almost level or gently undulating plain becomes slightly broken along the water courses, and the forests of Longleaf Pine are interrupted by wide, swampy bottoms which inclose the streams and are heavily timbered with the Loblolly Pine, Cuban Pine, Laurel Oak, Water Oak, Magnolia, White and Red Bay, and Cypress. On the better class of the pine-timber lands the amount of marketable timber found varies between 3,000 and 10,000 feet to the acre. The trees yielding lumber and square-sawn timber of the highest

[1] Kirk Hammond, Census Report, Vol. VI, Cotton production of South Carolina.

[2] Hammond, l c.

[3] Report of Tenth Census, Vol. IX.

[4] Lumber Trade Directory, Northwestern Lumberman, Chicago, July, 1890.

[5] From the so-called wire-grass *Aristida stricta*, the most characteristic plant of the dry, sandy, pine barrens from western Alabama to the Atlantic coast.

grade were found to make sticks of from 40 to 45 feet long, perfectly clear of limb knots, and 18 to 22 inches mean diameter, giving from 450 to 750 feet of lumber, with the sapwood from 1½ to 2 inches wide.

The following measurements of trees from a small tract of forest untouched by the ax serve as a fair average sample of its timber growth:

Number of tree.	Diameter, breast high.	Mean diameter.	Length of timber.	Total height.	Number of rings.
	Inches.	*Inches.*	*Feet.*	*Feet.*	
1	28	22	45	93	250
2	22	18	40	106	240
3	19	15	40	96	150
4	18	15	40	93	138
Average	21¾	17½	41¼	97	194

Along the numerous railroad lines and the navigable streams and their tributaries admitting of the driving of logs, the forests have been completely stripped of their merchantable timber, and the denuded areas to a considerable extent are at present under cultivation. The magnificent forests on the Altahama River and between its tributaries, the Ocmulgee and Oconee rivers, and also on the Ogeechee River, have been practically exhausted and are utterly devastated by the tapping of the trees for turpentine. In fact, more than two-thirds of all the timber sawn at present has been bled. The timber from the turpentine orchards, abandoned for years past, is being rapidly removed to the mills, and the vast areas occupied by them will, within a short time, be almost completely denuded of the Longleaf Pine, its place being taken by scrubby oaks, dwarf hickories, and Persimmon. The timber is transferred to the mills mostly by steam-equipped tramroads, and the products of the turpentine distilleries in the remoter districts are hauled to the highways of commerce by ox teams for distances of 12 miles and over.

Considering the removal for their timber of trees far below medium size and during the best period of their growth, the destruction of still younger trees by turpentine orcharding, and of the young seedlings by fire, the prospect for the future of the lumber industry and the renewal of the forests of Longleaf Pine in this region are gloomy. Many of the intelligent men practically interested in the timber lands of this State aver that the exhaustion of the forests of the Longleaf Pine is a question of but a short space of time, to be accomplished before another generation has passed.

The amount of timber standing at the end of the census year 1880 had been computed at 16,778,000,000 feet, board measure, and the cut at 272,743,000 feet.

From the publication quoted, it appears that in the year 1890 there were 88 sawmills in operation in the great pine belt of Georgia, sawing exclusively Longleaf Pine timber. On the basis of lowest figures cited, the daily cut at these establishments during that year would not fall short of 1,667,000 feet.

No statistical returns of the lumber trade previous to 1884 could be obtained at Savannah, Darien, or Brunswick. The export from the first of these ports averaged about 73,000,000 feet, board measure, a year, showing but slight fluctuation during the period beginning with 1884 to the close of 1889, when in the subsequent two years the annual average increased to 118,000,000 feet, board measure. The exports from Darien and Brunswick, averaging 82,000,000 and 85,000,000 feet, respectively, for a similar period of time, show also but small differences from one year to another. About 30,000,000 to 33,000,000 feet are rafted down the Flint and Chattahoochee rivers, to be sawn at Apalachicola. With the spread of the sawmills along the railroad lines in the upper part of the pine region, the shipments of lumber by rail to distant Northern markets increased steadily, until in 1892 it was found that the production of Longleaf Pine lumber shipped by rail to Northern markets exceeded 60,000,000 feet.

Tabular statement of exports of lumber from Savannah, Darien, Brunswick, and St. Marys to foreign and domestic ports and shipments by railroad to inland markets from 1883–84 to 1893–94.

Year.	Savannah.	Darien.	Brunswick.	St. Marys.	Savannah Railroad.	Otherwise by rail.	Flint River.	Total.
	Feet, B. M.	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*
1883–84	82,100,000	90,100,000	84,700,000	8,500,000				
1884–85	69,100,000	72,900,000	87,500,000	8,500,000				
1885–86	68,000,000	83,000,000	80,000,000					
1886–87	68,400,000	90,000,000	88,000,000					
1887–88	70,400,000	90,000,000	88,000,000					
1888–89	78,100,000	85,000,000	82,000,000					
1889–90	128,600,000	70,000,000	84,000,000					
1890–91	107,300,000	80,000,000	80,000,000					
1891–92	138,300,000	85,000,000	80,000,000		50,000,000	16,900,000	33,000,000	403,200,000
1892–93	116,100,000	85,000,000	80,000,000		50,000,000	16,000,000		347,000,000
1893–94	77,400,000	85,000,000	80,000,000		50,000,000			292,000,000
Total	935,800,000	833,000,000	834,200,000	17,000,000	150,000,000	32,900,000	33,000,000	

This makes a grand total for the ten years ended 1894 of 2,836,000,000 feet, board measure, with an aggregate value, at present export rates ($11 per 1,000 feet), of at least $31,196,000.

In the production of naval stores Georgia takes the lead. By the statements of the census of 1870, only 3,208 casks of spirits of turpentine and 13,840 barrels of rosin, valued at $95,970, were produced during that year in the State. In the course of the following ten years this industry progressed steadily and rapidly. In 1888 exports from Savannah, at present the greatest market in the world for these products, had increased to 168,000 casks of spirits of turpentine and 654,000 barrels of rosin, of a total value of $3,880,000.

Statement of exports of naval stores from Savannah during the years 1880–1894.

Year.	Spirits of turpentine.	Rosin.	Year.	Spirits of turpentine.	Rosin.
	Casks.	*Barrels.*		*Casks.*	*Barrels.*
1879–80	46,321	221,421	1888–89	159,931	577,990
1880–81	54,703	282,386	1889–90	181,542	716,658
1881–82	77,059	309,834	1890–91	196,227	770,311
1882–83	116,127	430,548	1891	196,166	758,448
1883–84	129,835	559,625	1892	234,986	873,678
1884–85	121,028	401,998	1893	277,617	1,032,198
1885–86	106,925	424,490	1894	261,081	957,027
1886–87	146,925	566,932			
1887–88	168,834	654,286	Total	2,475,297	9,637,830

Valued at $49,401,031.

The highest prices for these stores in Savannah were obtained in 1880, with $19.50 per cask of 50 gallons for spirits of turpentine and $2.25 per barrel of rosin of 280 pounds gross; and the lowest in 1887–88, with the price of spirits of turpentine at $14.25 per cask and $1.40 per barrel of rosin. On close scrutiny of the prices ruling at Wilmington, for the eleven years after 1880 the price of a cask of spirits of turpentine averaged $18 and of a barrel of rosin $1.90, lowest grades of the latter excluded.

Florida.—That part of the State between the Suwanee River and the Atlantic Coast, as far south as St. Augustine, can be considered as part of the Atlantic pine region, and covers an area of about 4,700 square miles. In the basin of the St. Johns River a large part of the land has been devoted to the cultivation of the citrus fruits. The principal sites of the manufacture of lumber in this section of the State are Ellaville, in Madison County, on the Suwanee River, and Jacksonville. The supplies once existing along the Cedar Keys and Fernandina Railroad are at present well-nigh exhausted. South of St. Augustine the Longleaf Pine is less common and in general inferior in size. The timber on the extensive flat woods to the Everglades, covered with the Saw Palmetto, is stunted and the forests are very open, and in the more fertile soils Longleaf Pine is largely replaced by Cuban Pine. In the central section of the peninsula, with its numerous lakes, the Longleaf Pine is largely associated with the Sand Pine (*Pinus clausa*), and hard woods prevail on the upland hummock lands.

THE MARITIME PINE BELT OF THE EASTERN GULF REGION.

From the banks of the Suwanee River to the uplands bordering the alluvial lands of the Mississippi this pine belt, varying from 90 to 125 miles in width, covers an area roughly estimated

at a little over 40,000 square miles. It presents no material differenees from the Atlantic region, of which it is a direct continuation, being similar to it in both soil and elimate.

This eastern Gulf region is unsurpassed in the advantages it offers for the development of the industries based on the products of the pine forests. Its genial climate throughout the year permits the uninterrupted exploitation of its abundant resources of resinous products and of timber of the best quality. The fine harbors and safe roadsteads on the Gulf Coast are reached by navigable rivers, which, with their tributaries, cross the lower division in every direction, and give ready and cheap transportation to its ports, while great railway lines afford easy communication with inland markets. This region thus presents inducements scarcely found elsewhere for the investment of capital and labor in the development of the resources of its forests.

It is impossible to arrive at anything like an accurate estimate of the amount of timber standing at present, or of the rate of its consumption, since in the returns of the annual lumber product that needed for home consumption has not been included.

Western Florida.—Placing the eastern limit of that part of Florida to be considered as belonging to the Gulf pine region at the lower course of the Suwanee River, the area included comprises about 7,200 square miles, exclusive of the swamps and marshes of the coast. The forests of Longleaf Pine form a narrow strip along the course of the Suwanee River and along the coast to the Appalachicola River, covering about 1,280,000 acres. At their northern limit they merge into the oak and hickory uplands of middle Florida. Along the coast they are surrounded by marshes and swamps, rendering them difficult of access, consequently they have remained untouched. The same may be said of the pine forests between the Appalachicola and the Choctawhatchee rivers. These have been invaded to some extent along the banks of the latter river to supply the small mills situated on the bay of the same name.

The pine lands of western Florida rise slowly above the coastal plain and form a vast expanse of slightly undulating surface. Those surrounding Perdido, Pensacola, Blackwater, and Mary St. Galves Bay, the oldest sites of active lumber industry in the Gulf region, were stripped of their valuable timber more than thirty years ago, and since that time have been cut over again.

The largest tracts of finely timbered virgin forests of Longleaf Pine are found in the undulating uplands from the Perdido and Escambia rivers along the Alabama State line to the banks of the Choctawhatchee River. East of this river, in the same direction, where the younger Tertiary strata make their appearance, Longleaf Pine becomes associated with hard woods, with southern Spruce Pine added in the valleys. Since the opening of the Pensacola and Atlantic Railroad considerable quantities of sawn square timber find their way to Pensacola from these remoter forests.

A large portion of the timber supplied to the mills along the coast having been derived from Alabama, it is impossible to arrive at an exact estimate of the products of the forest of western Florida.

Statement of export of hewn square timber, sawn square timber, and lumber to foreign and domestic ports from Pensacola, Fla., from 1879–80 to 1892–93.

[From Hyer & Bro.'s annual circulars.]

Year.	Square hewn timber.	Square sawn timber and lumber.	Total.
	Cubic feet.	*Feet, B. M.*	*Feet, B. M.*
1879–80	2,180,000	176,000,000	202,000,000
1880–81	4,603,000	209,998,000	264,000,000
1881–82	5,479,650	164,305,000	230,000,000
1882–83	2,169,000	188,100,000	211,386,000
1883–84	2,031,000	194,890,000	219,286,000
1884–85	1,627,000	195,576,000	211,131,000
1885–86	1,700,000	215,750,600	228,590,000
1886–87	1,036,000	231,884,600	245,221,000
1887–88	1,283,000	238,299,400	253,699,000
1888–89	1,574,000	310,255,000	329,153,000
1889–90	1,367,000	276,587,000	292,991,000
1890–91	1,550,133	254,125,000	271,728,800
1891–92	1,488,272	325,081,000	294,958,700
1892–93	1,449,910	252,808,000	270,208,000
Total			3,534,352,300

In the shipment of these products in 1885, valued at $2,305,500, there were 471 vessels engaged, of 294,595 tons, of which 370 of 95,922 tons cleared for foreign ports.

During these fourteen years the price of square timber and lumber taken in the aggregate averaged about $12.50 per 1,000 feet, board measure. On this basis the value of the mill products for these parts of the forests of Longleaf Pine amounted to $3,155,670 a year.

For the past forty years, during which the lands of the peninsula part and in middle Florida have passed mostly into possession of small proprietors, no naval stores have been produced in this section. In western Florida, however, in proximity to the Louisville and Nashville and Pensacola railroads, large areas have been subjected to the tapping of the trees, and the forests close to these railroads having been exhausted, the products of the turpentine stills are hauled for a distance often exceeding 10 miles and find their market mostly at Mobile.

Alabama.—Owing to the diversity in geological conditions and in topographical features prevailing in this State, the distribution of the Longleaf Pine presents within its borders peculiarities not found elsewhere. It appears in three separate regions—the maritime pine belt, the central pine belt, and the pine forests of the Coosa Basin and other outlying forests in north Alabama.

The coast pine belt extends from the Gulf shore inland for a distance of from 90 to 100 miles, and has been estimated to cover about 13,750 square miles, or 8,800,000 acres, outside of the swamps and flatwoods of the coast plain. The latter, perfectly level or rising in gentle swells above the tidewater marshes, is almost completely stripped of its original timber growth. After its removal the Longleaf Pine has largely been replaced by Cuban Pine.

The rolling pine uplands rise to a height of from 200 to 350 feet above the lowlands of the coast. In the lower part of this pine belt, where the sandy and gravelly deposits of the latest tertiary strata prevail, the Longleaf Pine forms pure forests, with the exception of the narrow strips of hardwood timber bordering the water courses. This lower division covers about 4,250,000 acres. In the extent and quality of their timber resources these Longleaf Pine forests can be considered equal to those found in the adjoining parts of Florida and in Mississippi, and unsurpassed by those of the most favored sections of the Atlantic pine forest.

The following measurements of trees felled near Wallace, Escambia County, in collecting the material for the United States timber tests, will serve to represent fairly the quality of the merchantable timber in conformity with the standard in vogue at the mills in 1880, and the relation of age to growth:

Measurements of five trees.

Number of tree.	Diameter, breast high.	Total height.	Rings on stump	Diameter below crown.	Mean diameter of timber.	Length of timber free of limb-knots.
	Inches.	*Feet.*		*Inches.*	*Inches.*	*Feet.*
1	26	106	216	18	22	50
2	19	111	189	14	16	60
3	16	111	183	12	14	45
4	18	113	196	15	17	50
5	19	113	182	13	16	50
Average	19.6	111	193	14.5	17	51

At a lumber camp near Lumberton, in Washington County, 9 timber trees were measured showing on the average a mean diameter of 17 inches, the clear sticks averaging 40 feet in length.

Upon 1 acre, selected at random in the untouched forests north of Springhill, Mobile County, very open and free from smaller trees or undergrowth, 16 trees were counted above 16 inches in diameter at breast high, namely, 2 trees 23 inches in diameter at breast high, estimated length of timber, 40 feet; 2 trees 20 inches in diameter at breast high, estimated length of timber, 40 feet; 12 trees 16 to 18 inches in diameter at breast high, estimated length of timber, 35 feet; which in the aggregate would yield about 5,000 feet, board measure.

Upon another acre plat of the same quarter section 64 trees above 12 inches in diameter at breast high were found; of these 2 trees measured 20 inches in diameter at breast high, estimated length of timber, 40 feet; 26 trees measured 17 inches in diameter at breast high, estimated length of timber, 36 feet; 36 trees measured 13 inches in diameter at breast high, estimated length of timber, 24 feet.

Upon a third plat exceptionally heavily timbered, 45 trees were counted, of which 5 trees were 25 inches in diameter at breast high, the clear timber averaging 50 feet in length; 12 trees 22 inches in diameter at breast high, length of timber 50 feet, and 28 trees 16 to 18 inches in diameter, average length of timber estimated at 30 feet. Such a stand would indicate a yield of merchantable timber of at least 15,000 feet, board measure, to the acre. All over this lower division boggy tracts are frequently met with, in which the sour, black soil is covered with sphagnum, or bog moss; these support only a few scattered pines. On many of the steeper ridges the soil is pure sand and the pine growth is small and inferior, being largely replaced by Barren Oak, Sparkleberry, and the evergreen heather-like shrub *Ceratiola ericoides*.

In this lower division of the maritime pine belt the manufacture of lumber and the production of naval stores is carried on most actively. These products find their outlet chiefly at Mobile, while more than one-third of the lumber exported from Pensacola (to the amount of at least 100,000,000 feet annually for the past few years) is also derived from this division. In the upper half of the maritime pine belt, with the appearance of the outcrops of limestones and limy marls of the Lower Tertiary (Eocene) formation, the country becomes more broken, with steeper hills and wider valleys, and a change in the character of the flora takes place, particularly manifest in the nature and distribution of the tree growth. In the fertile valleys and on the lower flanks of the hills broad-leaved trees, mostly Post Oak, Black Oak, Mockernut, Bitternut, Pignut, and Magnolia prevail, interspersed with Shortleaf Pine, Loblolly Pine, and Red Cedar—the Longleaf Pine occupying sporadic patches of drifted sands and pebbles. On the steep and frequently wide ridges capped by these deposits, and on the rugged hills of the buhrstone and flinty cherts this tree forms the principal growth, and is in the openings more or less associated with broad-leaved trees. From this commingling of cone-bearing and deciduous trees and the alternations of pine forest and oak woods, this upper division has been designated as the region of mixed growth, which at a rough estimate can be said to cover about 5,000 square miles.

In the deep soil of light loam and strong loamy sands the Longleaf Pine attains a splendid growth and the number of large trees on a given area is greater than found in the lower division. The following measurements of 5 trees felled for test logs fairly represent the average dimensions of the timber from these hills in the vicinity of Thomasville, Clarke County:

Measurements of five trees.

Number of tree.	Rings in stump.	Diameter breast high.	Diameter below crown, or top end of timber.	Mean diameter of timber.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*
16	202	20	15	18	45	108
17	163	21	14	17	40	115
18	210	22	16	19	40	110
19	160	26	19	22	40	111
20	110	17	13	15	30	92
Average	171	21.2	15.4	18.2	39	106.2

Many of the trees of larger size were found affected by wind-shake in the direction of the rings of growth (ring-shake), in many instances impairing greatly the quality of the timber. The forests on these hills are open, with a comparatively small number of young trees. Upon 1 acre selected at random 46 trees were counted; of this number were found 4 trees of a diameter of 25 inches breast high, and the length of timber about 40 feet; 10 trees of a diameter of 22 inches breast high, and the length of timber about 36 feet; 26 trees of a diameter of 18 inches breast high, and the length of timber about 30 feet; 6 trees of a diameter of 15 inches breast high, and the length of timber about 25 feet.

On the average each one of these trees would yield about 400 to 450 feet, board measure. On another acre 44 trees were found differing in their average dimension but slightly from the above, and indicating a yield between 18,000 and 19,000 feet of lumber to the acre. In this upper part of the coast pine belt lumbering and turpentine orcharding have not developed to any great extent, owing to its inaccessibility. However, where railroads traverse the section, the manufacture of

lumber is carried on extensively, the output going to Northern markets. Much of the heavy hewn timber that is exported from Mobile and Pensacola is furnished by this section.

In collecting the statistics on the lumbering interests in the maritime pine belt of Alabama the information kindly furnished by firms engaged in the sawmill business or the lumber trade has chiefly been relied upon. The annual production was arrived at by multiplying the average daily output reported by 200, the assumed number of working days of the year. From these data it appears that during the year 1893 the daily output of the 25 points reported from amounted in the aggregate to about 768,000 feet, or to 192,000,000 feet, board measure, for the year. This figure can be said to represent the average of the annual production for the past three years. To this amount, at a low estimate, 85,000,000 feet of round timber are to be added, cut in Alabama and sawn in western Florida, including the hewn square timber shipped from the State to Pensacola, thus swelling the present annual production of lumber and square timber in the maritime pine belt of Alabama to a total of about 277,000,000 feet, board measure. The statement of the annual exports of these products from Mobile by water and by rail for the past fourteen years will aptly illustrate the steady increase of the lumbering interests during this period.

Statement of exports of square timber, hewn and sawn, and of lumber shipped from Mobile to foreign and domestic ports from the year 1879–80 to the end of the year 1894.

Year.	Square timber, hewn and sawn.	Lumber.	Total lumber and square timber.	Value.
	Cubic feet.	*Feet, B. M.*	*Feet, B. M.*	
1879–80	745,000	13,572,000	22,525,000	$280,825
1880–81	1,725,000	18,161,000	38,872,000	400,348
1881–82	1,674,000	32,236,000	53,350,000	710,012
1882–83	1,652,804	26,753,843	46,588,000	582,000
1883–84	3,810,714	22,251,000	67,978,000	801,699
1884–85	3,121,794	22,256,000	59,945,000	636,953
1885–86	2,973,206	21,435,500	56,580,000	588,148
1886–87	1,863,259	29,346,000	60,723,000	641,215
1887–88	2,450,257	29,257,000	59,740,000	677,804
1888–89	3,049,440	48,284,000	100,000,000	1,081,828
1889–90	3,811,987	52,879,000	111,659,810	1,201,934
1890–91	3,592,924	50,892,000	122,000,000	1,415,000
1891–92	5,072,088	61,865,895	141,793,700	1,695,000
1892–93	5,377,009	79,304,565	162,666,700	1,590,900
1893–94	4,147,825	67,209,745	126,684,500	1,270,000

The first statement of the production of naval stores in Alabama is that reported to the census of 1850, mentioned in that year as of a value of $17,800. In 1870 the production had increased to 8,200 casks of spirits of turpentine and 53,175 barrels of rosin, valued at $280,203. In 1873 the receipts in the market of Mobile had fully doubled, amounting to nearly 20,000 casks of spirits of turpentine and to from 75,000 to 100,000 barrels of rosin, besides 1,000 barrels of tar and pitch, of a total value of $750,000. The largest production was reached in 1875, when the receipts reached a value of $1,200,000, up to the present only approximated in 1883 with 43,870 casks of spirits of turpentine and 200,025 barrels of rosin, valued at $1,109,760. Since 1888 a steady decline in the receipts of these products has taken place, due to the exhaustion of the supplies near the commercial highways.

Table of exports of naval stores from Mobile during the period of 1880–1894.

Year.	Spirits turpentine.	Rosin.	Total value.	Year.	Spirits turpentine.	Rosin.	Total value.
	Casks.	*Barrels.*			*Casks.*	*Barrels.*	
1879–80	25,209	158,482	.....	1887–88	28,725	132,055	.....
1880–81	25,224	170,616	.....	1888–89	23,927	106,129	.....
1881–82	30,937	172,438	.....	1889–90	21,029	93,906	.....
1882–83	43,870	200,125	.....	1890–91	21,686	89,872	$535,690
1883–84	41,804	210,572	.....	1891–92	22,172	87,926	458,002
1884–85	41,713	200,688	.....	1892–93	18,000	69,120	355,180
1885–86	38,733	175,817	.....	1893–94	24,091	85,619	453,656
1886–87	40,149	182,955	.....				

THE CENTRAL PINE BELT OF ALABAMA.

The middle portion of the State is crossed from its eastern boundary nearly to its western, with a decided northern trend along the western border, by a belt of drifted loamy sands, pebbles, and light loams covered in the eastern and central parts with an almost continuous forest of Longleaf Pine, interrupted only by strips of hard wood which occupy the bottom lands. In its eastern extent the Longleaf Pine becomes associated with upland oaks, hickories, and Shortleaf Pine, the Longleaf Pine being entirely replaced in the northern extension of this belt by the latter species.

This region of gravelly hills, as it is designated in the agricultural reports,[1] is 200 miles in length, 5 to 35 miles in width, and extends over about 2,000 square miles. In the sections where the forest consists almost exclusively of Longleaf Pine the stand of timber is heavy and of fine quality. Operators claim for these timber lands a yield of from 5,000 to 6,000 feet of merchantable timber to the acre, excluding all trees under 12 inches diameter.

Ever since the opening of the great railroad lines leading to Northern markets the manufacture of lumber in this central pine belt has been carried on with unabated activity. In 1880 not less than 80,000,000 feet, board measure, were transported by the Louisville and Nashville Railroad alone, mostly to the great Northwestern centers of commerce. In 1886 the production declined to 50,000,000 feet. At present most of the older mill sites have been abandoned and a few new ones established in other localities. Colonel Wadsworth reports 12 mills in operation located along the Louisville and Nashville Railroad, with an output of a little over 40,000,000 feet a year on the average of the past few years. To this is to be added the production of the few mills on the Mobile and Birmingham Railroad, which will increase the present production in the central pine belt to about 50,000,000 feet a year.

THE FORESTS OF LONGLEAF PINE IN NORTH ALABAMA.

Forests of Longleaf Pine prevail with more or less interruption in the basin of the Coosa River, principally on the beds of flinty pebbles and light, sandy loam which follow the upper course of the river from the base of the Lookout Mountain range near Gadsden to a short distance beyond the State line in Floyd County, Ga., where the Longleaf Pine finds its northern limit in about 34° north latitude, at an elevation above the sea of about 600 feet. With the reappearance of the above deposits south of Calhoun County the pine forests extend on the eastern side of the valley south to Childersburg. On the isolated ridges of old Silurian sandstone (Potsdam), and the metamorphic region adjoining, the Longleaf Pine is scattered and stunted and is not found at a greater height than 1,000 feet above the sea. In proximity to the mineral region the rugged hills and mountain sides have been completely denuded, the pine having been cut for charcoal to supply the blast furnaces. In the valleys the forests of Longleaf Pine are of average density and the timber is considered of excellent quality, particularly in the northern part of the valley in Etowah and Cherokee counties. On the lower hills the timber is less abundant and somewhat inferior in size. The measurements of five trees felled in the hills near Renfroe, Talladega County, can be said to fairly represent the average quality of this pine timber. The undergrowth in the open forest covering the low ridges and the narrow valleys is dense, consisting of Blackjack, Spanish Oak, Pignut, and Bitternut Hickory.

Measurements of five trees.

Number of tree.	Rings on stump.	Diameter breast high.	Mean diameter.	Length of timber.	Total height of trees.
		Inches.	*Inches.*	*Feet.*	*Feet.*
237	135	17	12	50	95
238	165	21	17	35	95
239	170	21	18	45	108
240	215	21	18	45	112
241	206	20	15	50	109
Average	178	20	16	45	104

[1] E. A. Smith: Agricultural Resources of Alabama, Vol. V. Reports of Geological Survey of Alabama.

The extinction of Longleaf Pine in the forests of north Alabama, as far as economic value is concerned, appears to be certain. The dense undergrowth of deciduous trees suppresses completely the second growth of the Longleaf Pine in the closed forest as well as in the openings. On the mountain slopes a young pine is rarely seen, no tree being left to serve for the future dissemination of the species, and the few seedlings sporadically springing up are invariably destroyed by the firing of the herbage one year after another.

The output of the mills at Gadsden and the mills in Talladega County along the Birmingham and Atlantic Railroad combined appears scarcely to exceed 50,000,000 feet, board measure, on the average per year. A fine forest of Longleaf Pine is found in Walker County, strictly confined within an isolated patch of silicious pebbles and sands, said to cover about 60,000 acres. Distant about 10 miles from the nearest railroad this forest has been but slightly invaded, and that to serve a small local demand.

Summary statement of shipments of lumber and square timber from chief centers of production in Alabama during the year 1892.

	Feet, B. M.
Mobile exports to foreign ports, coastwise, and shipments by rail[1]	143,800,000
Estimated cut in Alabama and sawn in western Florida	85,000,000
Transported by rail, mostly to northern markets[2]	95,200,000
Central pine belt[3]	51,000,000
Coosa basin[4]	50,000,000
Total	425,000,000

Mississippi.—What has been said of the forests of the maritime pine belt in Alabama applies in general to the same region in Mississippi. The coastal plain above the extensive grassy marshes lining the seashore and the wide estuaries of the streams covers a larger area, being from 10 to 20 miles in width and embracing, at a rough estimate, about 728,000 acres of the 16,410 square miles within the limits of the pine belt. The broad, scarcely perceptible swells, with a soil of sandy loam and loamy sand, were originally well timbered, the widely spreading depressions with soil of fine, compacted sand, poorly drained, bearing a sparse and inferior timber growth. The timber produced on these flat woods, or "pine meadows," as they are aptly called in the adjoining section of Alabama, being of slow growth, is hard and of fine grain, frequently with the fibers of the younger wood contorted and of varied tints of color. This so-called curled pine is susceptible of high finish and is much appreciated for fine cabinet work. There is comparatively little valuable timber left in this coastal plain. The remainder serves largely for the making of charcoal and cord wood for the New Orleans market.

The rolling pine lands, rising suddenly above the plain, almost exclusively covered by the Longleaf Pine, cover (roughly estimated) about 7,712,000 acres. The western limits of these forests are difficult to define, numerous outlying tracts being found to extend into or even beyond the region of the loamy hills. The region of mixed growth, characterizing the upper division of the maritime pine belt in Alabama, enters the State in the shape of a triangle, with the base along the Alabama State line from Bucatunna to Lauderdale and its apex near Brandon, in Rankin County. The generous soil of the arable lands in this region is mostly under cultivation. The forests of Longleaf Pine covering the steep hills, rather remote from the high roads of commerce, have been as yet but little exploited. About 12,000,000 feet, board measure, of lumber are shipped annually by the way of the Mobile and Ohio Railroad, mostly to Mobile, from this region of mixed growth.

From the information that could be obtained, it appears that the cut of Longleaf Pine timber in this State on the average for the past three years reached between 422,000,000 and 425,000,000 feet. The chief center of the lumbering industry is located above the Pascagoula River, at Scranton and Mosspoint, where it has made great progress during the past thirteen or fourteen years. In 1880, 60,000,000 feet, board measure, were shipped to foreign and domestic ports, which in the

[1] Annual statement of commerce of Mobile. Mobile Register, September 1, 1892. Compiled from returns made to the Mobile Board of Trade.

[2] Production of mills south of Montgomery, etc.

[3] Production of mills on Louisville and Nashville Railroad, north of Montgomery to Calera, by Colonel Wadsworth.

[4] Production of mills on Southern Railway, north of Selma to Stanton, by M. Hanson.

year 1892 had increased to 127,000,000. Comparatively much larger increase is noticeable in the shipments by rail to inland markets. By the reports courteously furnished by the auditor of the Illinois Central Railroad in Chicago, in 1880, 12,000,000 feet, board measure, reached Northern markets by this line, which in 1888 had risen to 62,000,000, with a falling off in the succeeding year to 52,000,000. In 1892 the shipments increased again to 78,240,000, and reached in 1893 181,424,000 feet, board measure.

With the opening of the New Orleans and Northeastern Railroad, in 1883, the lumbering industry took an active start in the virgin pineries. In 1892 fourteen mills are on record, with a daily capacity of not less than 400,000 feet; this amount corresponding fully to the actual output for 1891 as well as 1892. According to Mr. Rich, of Richburg, in consequence of the depression during the year 1893, the output was reduced about one-half.

The following table of partial data regarding annual shipments, made during the thirteen years ending with 1893, from the chief centers of production shows clearly the constant increase of the lumbering industry since the close of the year 1880:

Tabular statement of lumber shipped annually by water and by rail from the centers of production in Mississippi, 1879–80, 1883–93.

Year.	Pascagoula River.	Pearl River Basin.	New Orleans and Northeastern Railroad.	Illinois Central Railroad.
	Feet, B. M.	*Feet, B. M.*	*Feet, B. M.*	*Feet, B. M.*
1879–80	60,000,000	35,000,000	.....	12,000,000.
1883–84	67,308,000	35,000,000	.....	28,000,000
1884–85	67,839,000	.....	.....	36,000,000
1885–86	.....	.....	.....	30,000,000
1886–87	70,000,000	.....	.....	40,000,000
1887–88	.....	.....	.....	62,000,000
1888–89	107,000,000	36,000,000	55,000,000	52,000,000
1889–90	119,255,000	.....	(*a*)	64,000,000
1890–91	170,000,000	35,000,000	.....	.....
1891–92	127,002,000	36,000,000	.....	78,240,000
1892–93	.....	.....	.....	181,424,000

a From 60,000,000 to 90,000,000.

RECAPITULATION FOR 1891–92.

Pascagoula River	127,000,000
Pearl River Basin	36,000,000
Illinois Central Railroad	78,000,000
New Orleans and Northeastern Railroad	60,000,000
Mobile and Ohio Railroad	12,000,000
Other points	20,000,000
Total	333,000,000

From this amount are to be deducted about 18,000,000 feet of lumber received from Mobile to complete cargoes, and 12,000,000 feet of timber cut on the western frontier of Alabama and finding an outlet at Pascagoula by the Escatawpa River, leaving a round 300,000,000 feet, board measure, for the cut in Mississippi in 1892, against 108,000,000, the cut reported to the census in 1880.

With the exhaustion of the forests along the Pascagoula and Escatawpa rivers and a few points between these streams and the Pearl River, which had been accomplished before the beginning of 1880, the naval-store industry remained almost dormant in the State until it began to receive a new start by the opening of the New Orleans and Northeastern Railroad. The production of the distilleries along this road can be said to average about 15,000 casks of spirits of turpentine and 75,000 barrels of rosin annually since 1890, which are mostly disposed of in the New Orleans market.

Eastern Louisiana.—Forests of Longleaf Pine cover the upper part of eastern Louisiana to the extent of about 3,880 square miles. Their western limit might be said to follow the Amite River, but can not be clearly defined, since these forests toward the west pass gradually into the mixed growth of Shortleaf Pine, oaks, and hickories on the uplands which border the bottom lands of the Mississippi River. Slightly undulating flat woods cover fully one-fifth of the area, and, with a somewhat loamy, porous soil, support a better timber growth than is generally found in the flat pine barrens of the plain. Owing to their proximity to the coast, these forests have been extensively invaded. The pine hills embrace about 1,619,200 acres. Their forests have remained almost intact, their resources having been drawn upon only along the Illinois Central Railroad line and the tributaries of the Pearl River.

In 1890 seven sawmills were reported, with a daily capacity, in the aggregate, of about 120,000 feet, board measure. It can safely be assumed that their annual output would not exceed 15,000,000 feet, board measure. The products of these mills find their market chiefly at New Orleans. In former years a considerable quantity of naval stores was produced in St. Tammany Parish, while at present only a few turpentine orchards are worked in the upper districts.

THE REGION OF LONGLEAF PINE WEST OF THE MISSISSIPPI.

The importance of the pine forests in the western Gulf region can not be overestimated, considering the development of the immense timberless area beyond their western limit. The rapidly increasing population of the Western plains depends chiefly upon them for the supply of the material needed to build up the homes of civilization.

The forests of the Longleaf Pine west of the Mississippi River, as in regions so far considered, are geographically limited to the sands and gravels of the latest Tertiary formation. They make their first appearance in Louisiana above the great alluvial plain in the uplands bordering the valley of the Ouachita and follow its course for 50 miles, then extend west, skirting Lake Catahoula and the alluvial lands of the Red River. These pine forests to the north of this river cover an area estimated at 1,625,000 acres, extending northward for a distance averaging 55 miles. Toward their northern limit the forests pass gradually into a mixed growth of deciduous trees and Shortleaf Pine. In the center of this region the pine ridges alternate with tracts of White Oak and Hickory. Tending toward the Red River, the pure forest of Longleaf Pine which covers the undulating uplands is unbroken and has up to the present been but slightly invaded by the ax. On the low hills of this northern division of the pine belt of northwestern Louisiana the forests are somewhat open, and are composed of trees of the first order as regards their dimensions, the well-drained, warm, and deep soil of sandy loam being highly favorable to their development. This fact is clearly shown in the following statement of the ages and dimensions of six trees felled for test logs:

Measurements of six trees.

Number of tree.	Rings on stump.	Diameter breast high.	Diameter below crown.	Mean diameter.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*
175	270	32	22	26	48	123
176	158	27	20	22	50	127
177	155	22	18	19	50	122
178	170	20	15	16	40	117
179	165	17	13	14	35	118
180	112	16	.....	.....	40	97
Average	171	22	17.6	19	44	117

Upon 1 acre of the same plat, with the timber standing rather above the average, 38 trees were found. Of these there were 14 of 24 inches diameter at breast high, estimated length of timber, 45 feet; 6 of 19 inches diameter at breast high, estimated length of timber, 40 feet; 9 of 17 inches diameter at breast high, estimated length of timber, 35 feet; 9 of 13 inches diameter at breast high, estimated length of timber, 30 feet.

In the opinion of experts, the average yield of 1 acre of these pine lands at a fair estimate is not less than 6,000 feet, board measure.

According to the statements of Mr. Sues, at Levins Station, 56,000,000 feet, board measure, were shipped, in 1892, from the mills of this section.

South of the Red River bottom the forests of Longleaf Pine continue unbroken to the Sabine River and south to the treeless savannas of the coast in Calcasieu Parish, their eastern boundary parallel with the eastern boundary of that parish. Roughly estimated, these forests cover an area of about 2,668,000 acres. From the marshy lowlands of the coast to the upper tributaries of the Calcasieu River, up to Hickory and Beckwith creeks, the country is poorly drained, almost perfectly level, with a highly retentive and somewhat impervious clay subsoil. In consequence, these pine flats are, for the greater part of the year, more or less covered with water. These low, wet pine forests were stripped some years ago of all their merchantable timber, and only a comparatively small number of trees of less than 12 inches in diameter were left standing. On

these abandoned timber lands a young pine is rarely seen, the seeds shed in the fall being apt to rot in the water-soaked soil, or, if they happen to germinate, the seedlings are drowned during the winter rains. On the lands rising gently above the flat woods, with the ridges still low and wide and often more or less imperfectly drained, Longleaf Pine is found of an exceedingly fine growth. The trees in the dense forest are tall and slender, and their timber is equaled only by the timber of the same class growing in the valley of the Neches River, in Texas.

The following measurements of five trees felled for test logs in the forests in the upper part of Calcasieu Parish, between Hickory and Beckwith creeks, will serve as a fair representation of the timber growth on these low, broad ridges:

Measurements of five trees.

Number of tree.	Rings on stump.	Diameter breast high.	Diameter below crown.	Mean diameter.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*
201	196	28	23	24	50	119
202	195	23	16	19	50	127
203	190	21	14	17	40	117
204	180	19	15	17	40	102
205	167	16	13	14	37	127
Average	185	21	16	18	43	118

Upon 1 acre, selected on the back of a low swell which might be said to represent the average of the timber standing, 44 trees in all were counted. Of these, 3 trees measured 25 inches diameter at breast high, with a length of clear timber estimated at 50 feet; 6 trees measured 23 inches diameter at breast high, with a length of clear timber estimated at 50 feet; 19 trees measured 18 inches diameter at breast high, with a length of clear timber estimated at 40 feet; 14 trees measured 14 inches diameter at breast high, with a length of clear timber estimated at 36 feet, corresponding in the aggregate to somewhat over 15,000 feet, board measure.

On another acre considered first class, rather level land, the soil fresh to wet throughout the year, 72 trees were counted. Of this number, 14 were found 27 inches diameter at breast high, with an estimated length of timber of 50 feet; 5 were found 24 inches diameter at breast high, with an estimated length of timber of 50 feet; 13 were found 23 inches diameter at breast high, with an estimated length of timber of 50 feet; 8 were found 21 inches diameter at breast high, with an estimated length of timber of 40 feet; 10 were found 20 inches diameter at breast high, with an estimated length of timber of 40 feet; 11 were found 18 inches diameter at breast high, with an estimated length of timber of 40 feet; 11 were found 18 inches diameter at breast high, with an estimated length of timber of 36 feet.

According to these figures the timber standing on this acre would amount to not less than 35,000 feet, board measure.

The chief site of the lumber industry of western Louisiana is at Lake Charles. According to the information furnished by Mr. George Lock, of Lockport, La., the annual output of the sawmills in the vicinity of Lake Charles for the years 1892 and 1893 averaged about 154,000,000 feet, board measure, all shipped West and Northwest. It can be assumed that over one-half of the lumber sawn at Orange, in Texas, is cut on the eastern banks of the Sabine River, which amount has to be credited to the cut of Louisiana.

Summary of the production of Longleaf Pine lumber in the State of Louisiana in 1892.

	Feet, B. M.
Parishes east of the Mississippi, about	25,000,000
Parishes north of the Red River	56,000,000
To the Sabine River, sawn at Lake Charles	154,000,000
Sawn at Orange, Tex., estimated	40,000,000
Total cut in Louisiana	275,000,000

Texas.—The forests of Longleaf Pine extend from the Sabine west to the Trinity River and from the grassy savannas of the coast region north to the center of Sabine, San Augustine, and

Angelina counties, and include an area of about 2,890,000 acres. In amount and quality of the timber these forests are unsurpassed and are only equaled by the forest of the adjoining region in Louisiana. Toward their southern borders the country, like the pine flats of southwestern Louisiana, is perfectly level and poorly drained, with the soil water-soaked for a greater part of the year. These flats have been almost completely stripped of their merchantable timber. North of Nona the surface rises gradually above the water level in broad, low swells, and, being underlaid by strata of stiff loams, is more or less deficient in drainage. The intervening wide flats are frequently covered with a dense growth of large shrubs and small-sized trees, consisting of various species of hawthorn (*Cratægus crus-galli*, *C. viridis*, *C. mollis*, *C. berberidifolia*), the Deciduous Holly (*Ilex decidua*), Dahoon Holly (*Ilex caroliniana*), Privet (*Adelia acuminata*), plane trees, and magnolias. These impenetrable thickets are common, and often cover many square miles, like the so-called Big Thicket in the lower part of Hardin County, said to be from 10 to 15 miles wide, either way. The growth of Longleaf Pine which covers the gentle, wide swells, is dense, of fine proportions, and of remarkably rapid development. The average age of five trees felled northwest of Nona, 15 to 25 inches in diameter, is but little over one hundred and fifty years, as the following measurements show:

Measurements of five trees.

Number of tree.	Rings on stump.	Diameter breast high.	Mean diameter.	Length of timber.	Total height of tree.
		Inches.	*Inches.*	*Feet.*	*Feet.*
188	240	26	20	40	110
189	208	22	19	50	101
190	105	18	16	50	113
191	113	21	18	45	110
192	94	15	12	40	107
Average	152	20	17	45	104

In this region, owing to the direct communication of several railroad lines with the great centers of trade in the North and with the treeless plains of the far West, the manufacture of lumber has made a wonderful progress during the past twelve years. In 1880 the cut of Longleaf Pine in this State has been estimated at 66,450,000 feet. From information received from parties engaged in the lumber business, the cut during the year 1892 can safely be estimated at 440,000,000 feet. The centers of lumber production are Orange and Beaumont, but a great amount is cut at the mills along the several lines of railway passing through this region.

Output of Longleaf Pine lumber in Texas during the year 1892.

	Feet, B. M.
Orange (inclusive of 40,000,000 of feet derived from Calcasieu)	45,000,000
Beaumont	75,000,000
Sabine Valley, Texas and Northern Railroad	157,000,000
Missouri, Kansas and Texas Railroad	143,000,000
Houston, Kansas and Texas Railroad	20,000,000
Total	440,000,000

For the renewal of the forests of Longleaf Pine in this region there is as little hope under their present management as in the adjoining region in Louisiana. In this cold, wet soil the seeds find but a poor chance for germination, and the surviving plantlets soon succumb to the same cause. In the pine flats seedlings are rarely observed among the tall broom sedge grasses (*Andropogon*) which, under the influence of light and a damp soil, thrive luxuriantly in the flat woods denuded of their timber growth, imparting to them the aspect of waving meadows or savannas.

PRODUCTS.

VALUE AND USES OF THE WOOD.

The wood of the Longleaf Pine is hardly surpassed by any of our timber trees of economic importance, and is practically unsurpassed by any member of its own order in the qualities which are required for purposes of construction, thus taking the first place among its congeners.

The timber from the damp flat woods of the coastal plain east of the Mississippi River, with a soil of almost pure, fine, closely compacted sand, is of slow growth and generally of the finest grain, often exhibiting in the sapwood that irregularity known as "curly pine." In the perpetually damp to wet soil of the pine flats in southwestern Louisiana and in Texas, with a deep retentive subsoil richer in nutritive elements, causing a better and quicker development of the tree, the wood is of a more open grain. Owing to the excellent qualities of the wood of Longleaf Pine, its use in the various mechanical arts and industries is as extensive as it is manifold. Its greatest value rests in its adaptability for heavy constructions—in naval architecture, for masts and spars; in civil engineering, for the building of bridges, viaducts, trestlework, and for supports in the construction of buildings. Large quantities of long and heavy sticks of square timber sawn or hewn for such purposes are shipped to the British ports and to the dockyards of the European continent, with a constantly increasing demand.

In the building of railroad cars, where great strength and elasticity is needed, the timber of Longleaf Pine is preferred to any other. For this purpose sticks from 36 to 42 feet, 10 by 12 inches, are required, free from blemish.

Enormous quantities of the younger timber of this tree are cut every year to serve for cross-ties, used by the railroads not only in the pine regions, but in other parts of the country. The demand for these ties forms a constant and increasing draft upon the forest. The ties delivered are, on the average, 8½ feet long, 9 inches wide, and 7 inches thick, and must be all heartwood and free from blemish. The trees selected for this purpose are from 15 to 16 inches in diameter, and preferably only the butt cuts are accepted. On an average 10 cross-ties are cut from 1 acre, each tie representing a log which would make at least 75 superficial feet of lumber. Since such a tie, ready for the roadbed, contains not more than 50 feet, board measure, it will be readily seen what an enormous waste results from this practice.

On the damp, sandy tracts of the lower South, such ties will last five or six years, and 3,000 ties are needed for 1 mile of road. Hence, for the construction of the 3,240 miles of railroad traversing the forest of Longleaf Pine east of the Mississippi River, nearly 10,000,000 ties have been required, which being renewed every six years involves an annual cut of 116,000,000 feet, board measure, to which must be added the amount exported to other regions.

In the Southern States, the West Indies, many places on the coast of Mexico, and Central and South America the lumber of the Longleaf Pine forms the chief, if not the only, material in the construction of houses. For similar purposes considerable quantities are of late years shipped to Northern markets, East and West, replacing in many cases, at least in parts of the buildings, the lumber of the White Pine, on account of its increasing scarcity. The fine-grained and "curly" varieties of Longleaf Pine lumber, by their beauty and the high polish of which they are susceptible, begin, of late years, to take a place among the higher-priced kinds of wood for ornamental inside work.

The importance and value of Longleaf Pine lumber as a material for constructions can not be better evidenced than by the fact that little less than 1,500,000,000 feet, board measure, or about one-third of all the lumber manufactured in the South, is being exported from Southern ports annually to domestic and foreign ports, besides furnishing almost the only material used at home in the construction of dwellings and all kinds of buildings. It also supplies material for furniture, as well as fuel, both in the form of firewood and charcoal, and its exploitation affords the means of subsistence to thousands.

Lightwood.—Whenever the sapwood of the tree is laid bare copious exudation of resin takes place and the surrounding wood becomes charged with it. Thus the wood of the trunks of the trees tapped for the extraction of their resin soon becomes charged with this along the scarified surface, and, as with the evaporation of water from the dead wood, the resinification proceeds and the wood increases in weight and durability. In low, damp places particularly this process takes place more extensively. This resin-charged wood is termed lightwood. The lightwood timber, considered very durable when exposed to alternating conditions of moisture and dryness, is much preferred for posts, etc. Being highly inflammable, it serves for torches and kindling, and hence its name. Of late years a profitable industry has been started to utilize the resinous stumps of abandoned orchards as kindling material by cutting the same close to the ground and then, veneer

fashion, into long, narrow strips three-fourths of an inch thick, which are subsequently steamed and rolled in small bundles to make a convenient package for shipment. The knots, limbs, roots—particularly "fat," i. e., highly charged with resin—are used in the making of tar.

Charcoal burning.—Where a market is found the trees left standing, after the removal of the larger timber fit for sawlogs, are burned for charcoal. This industry is carried on to a greater or less extent in the mineral regions to supply the blast furnaces operated for the manufacture of charcoal iron. Large areas of the forests of the Longleaf, covering the hills in north Alabama, have been entirely denuded of their tree covering to meet the demands for such purpose.

Fuel value.—The air-dry wood of the Longleaf Pine is much esteemed for fuel; containing but a small percentage of ash—not over 0.25 per cent—with a small amount of water, and a dense and close fiber, as indicated by its high specific gravity, its fuel value is necessarily high. Being also easily inflammable, it is preferred where quick and intense heat is required, as, for instance, in bakeries, brick kilns, potteries, etc., and in the raising of steam for stationary engines on steamboats and railroad locomotives throughout the pine region, where mineral coal can not be cheaply obtained.

RESINOUS PRODUCTS OF THE LONGLEAF PINE.

It can safely be asserted that among the trees of the same order there is found no other equally rich in resin. The manufacture of naval stores from the resin of the Longleaf Pine forms one of the most widely developed industries in the pine forests of the coast pine belt of the Southern States, and is scarcely less important than the manufacture of its lumber. A full account of these industries will be found in the accompanying appendix. Concerning the manufacture of tar, pitch, tar oils, and other products of destructive distillation of the wood and of rosin oil, see the Report of the Chief of Forestry, 1892, page 356, etc.

PRODUCTS OBTAINED FROM THE LEAVES OF LONGLEAF PINE.

The green leaves of the tree furnish by distillation an essential oil of balsamic odor closely resembling spirits of turpentine. The so-called pine wool is made from their cellular tissue, being treated with a strong alkaline solution at boiling heat, the remaining fiber being cleaned and carded. This pine wool is used in upholstery, and is said to be of value as an antiseptic dressing for wounds. Of late years it is manufactured into various kinds of textile fabrics. One fabric is a carpet which resembles cocoa matting somewhat, but is closely woven and is naturally of a rich-brown color and very durable. This industry, only recently established, has already met such success that the manufacturers have added twenty nine looms to their work.

NOMENCLATURE AND CLASSIFICATION.

This tree was first described by Miller in the year 1768 under the name of *Pinus palustris.* The younger Michaux substituted for it the more appropriate one of *Pinus australis*, under which name it was described by succeeding writers and generally known to botanists of recent date. To satisfy the law of priority, the name given by Michaux has recently been dropped and the old one reinstated, in the Catalogue of North American Forest Trees,[1] published in the ninth volume of the census reports of 1880. (See vernacular nomenclature in introduction.)

BOTANICAL DESCRIPTION AND MORPHOLOGY.

Leaves three, in a long light-colored sheath; commonly from 9 to 13 (sometimes 14 to 15) inches long; of a bright green color and closely set in brush-like clusters at the ends of the stout branches. Cones large, dark tan colored, 6 to sometimes 8 inches long and 2 to 2½ inches in diameter when closed, 5 to 6 inches when open; scales about 2 inches long and one-half to 1 inch wide—rather uniform in width—somewhat thickened at the ends, and bearing a rather delicate incurved prickle; seed large, slightly triangular, three-eighths to seven sixteenths of an inch long and one-fourth of an inch wide; often with two or three longitudinal ridges on one face; whitish, with few or abundant brown specks; wing 1½ to 2 inches long and of a glossy brownish to deep purple-brown color.

The most conspicuous and distinguishing feature of this species is the silvery thick terminal bud, or rather the bud-like clusters of the young leaves inclosed in their finely fringed subtending scales. Its branches are rough, covered with the bases of the imbricated leaf scales, the elongated silvery fringes having fallen off.

[1] A catalogue of North American Forest Trees, exclusive of Mexico, by C. S. Sargent.

ROOT, STEM, AND BRANCH SYSTEM.

The Longleaf Pine attains a height averaging 100 feet, rarely exceeding 110 feet, with a diameter breast high, when fully grown, varying between 20 and 36 inches, rarely more. The tall, straight, very gradually tapering trunk arises from a massive taproot which, in favorable situations, penetrates the soil to a depth of from 12 to 15 feet, and sometimes much more. It has several stout, comparatively short lateral roots, which assist the tree in its hold by slanting deeply into the ground, and some of greater length are placed more or less near the surface. Its crown is open and elongated, of irregular shape, about one half to one-third of its height. The stout limbs are rarely over 20 feet in length, twisted and gnarled and sparingly branched. The trunk is covered with a reddish-brown bark, one-fourth to three-fourths of an inch thick, furrowed throughout its full length, crossed horizontally by deep fissures, and scaling off in thin, bluish, almost transparent rhombic flakes.

LEAVES AND THEIR MODIFICATIONS.

Like all the pines, this species produces during various stages of its growth seven different modifications of leaves as recognized by botanists, all more or less specific in character:

(1) Cotyledonary, or seed leaves (first leaves of the embryo), which soon wither and disappear (Pl. VII, *a*, *b*). (2) Primary leaves succeeding the former immediately on the main axis (Pl. VII, *c*), which either wither or later on are transformed into, or succeeded by, more or less permanent bracts or scales covering the branches (Pl. V, *a*). (3) The secondary or foliage leaves rising from the buds produced in the axils of the primary leaves or of the bud scales by which they are represented (Pl. VII, *d*), permanent foliage of the tree, with three leaves in one sheath. (4) The bud scales forming the sheaths of the foliage leaves (Pl. IV, *b*, *c*, *d*) at base. (5) Involucral bracts of the male flower (Pl. V, *f*). (6) Involucral scales of the female inflorescence (ament) (Pl. V, *c*). (7) The bracts which support the carpellary scale bearing the seed (Pl. V, *h*).[1]

The primary leaves, which succeed the cotyledons on the primary axis, are in form and structure true leaves. They are softer than the final foliage leaves, have a broad base, are rounded on the dorsal side and not channeled, the whitish transparent margins being finely but distinctly denticulate. It is rare that secondary leaves proceed from the axils of these chlorophyll-bearing primary leaves. With the more frequent appearance of the ordinary leaves, these primary leaves wither and henceforth appear as triangular scale-like coriaceous persistent bracts, with broad, hyaline, long-fringed edges, in the axils of which the undeveloped branchlets are produced bearing the secondary or foliage leaves.

The chlorophyll-bearing primary leaves exhibit a simple structure. The fibro-vascular bundle is single, embedded in a wider ring of large cells free from chlorophyll, and the resinous ducts fewer in number, one, or rarely more than two, being irregularly situated in the chlorophyll-bearing parenchymatous tissues, and mostly external, i. e., close to the thick epidermis. But few of these leaves are formed after the appearance of the foliage leaves, and a few of them persist throughout the first season.[2] The cataphyllary leaves forming the sheath of the foliage leaves are in this species composed of eight successive pairs of bud scales; those of the first pair are blunt, flat, deeply concave and coriaceous, with sharp edges; the others are more membranaceous and with fringed edges, the closely interwoven edges entwining the base of the fascicle. In the secondary leaves the very numerous stomata form, on both sides, regular longitudinal rows. Parallel with these, at regular distances between them and embedded in the parenchymatous tissue, are found bundles of numerous, elongated, thick-walled cells, the so-called hypodermal or strengthening cells. The resin ducts, not over five in number, described by Engelmann as internal, have been found in the specimen examined rather parenchymatous, invariably so on the dorsal side.

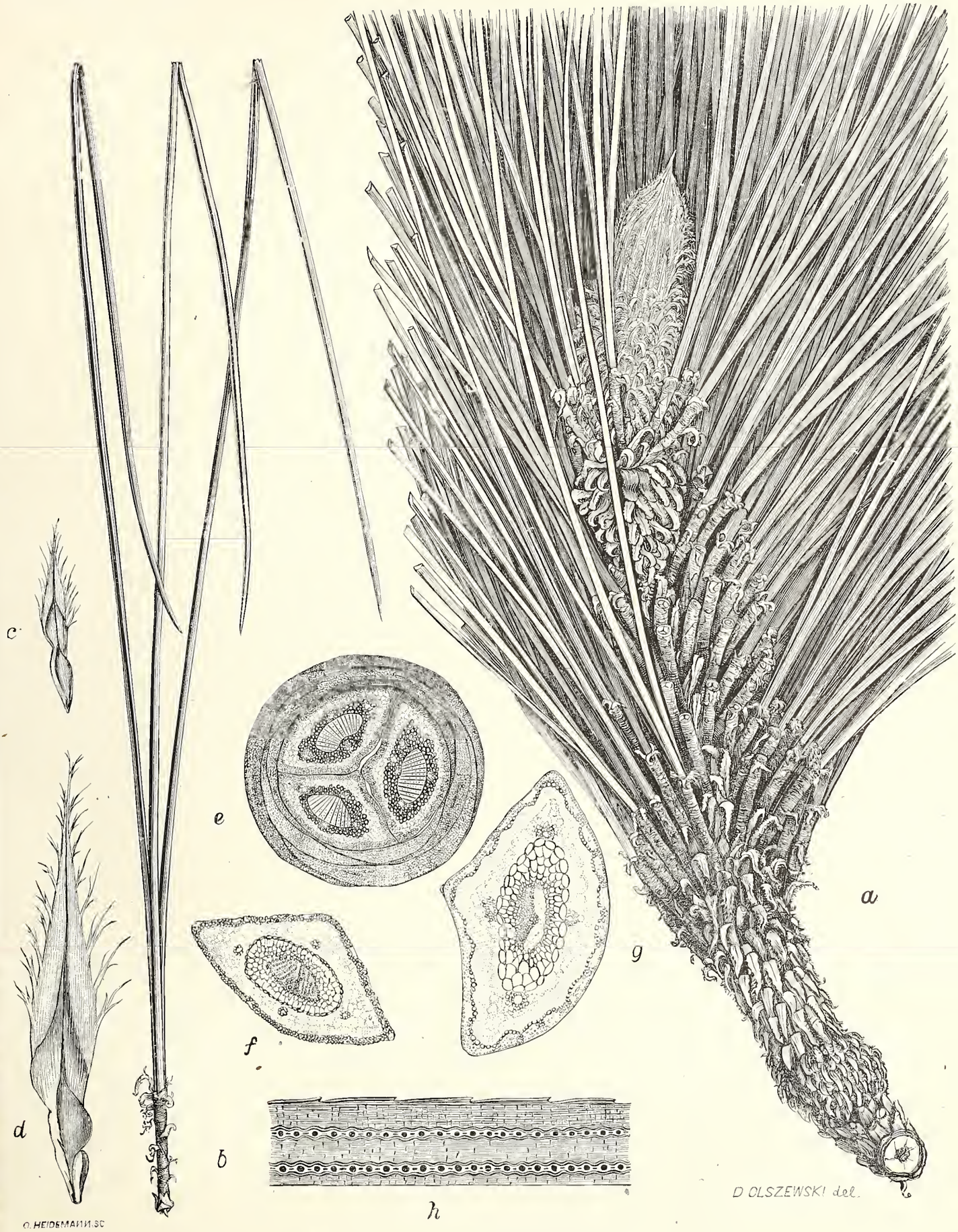
Three of the secondary or true foliage leaves are united into one bundle, inclosed at the base by a persistent sheath from one-half inch to an inch in length, formed by the bud scales or cataphyllary leaves. On the older trees the leaves are rarely over 8 inches in length, but during the periods of most active growth they are found 12 to 18 inches long. They are finely serrulate, rounded on the back, channeled, and obtusely triangular in cross section.

[1] George Engelmann: Revision of the Genus Pinus. Transactions of the St. Louis Academy of Science, 1882.

[2] Engelmann: Revision of Genus Pinus. Trans. St. Louis Academy of Science, 1882, p. 5.

EXPLANATION OF PLATE IV.

Fig. *a*, branch showing the terminal spring shoot of the season with characteristic, large silvery white winter bud; the bundles of leaves arise from the axils of the leaf-bracts of the last two seasons, the first leaves of the second year already shed; *b*, detached bundle of mature leaves with sheath; *c*, *d*, scales of the sheath, magnified three and nine times; *e*, transverse section through base of leaf bundle showing imbrication of sheath scales, magnified 30 diameters; *f*, transverse section of an immature leaf, magnified 30 diameters; *g*, transverse section of a mature leaf, magnified 45 diameters, showing the microscopic structure (as pointed out for *P. echinata*, *f*, *f*); *h*, longitudinal section of the dorsal side of a mature leaf showing two rows of stomata and the serrated edge, magnified 45 diameters.



PINUS PALUSTRIS: BUD AND LEAF.

Owing to the shedding of the older leaves at the end of the second year and to the short annual growth of the axis, the leaves on the older trees are conspicuously crowded into dense tufts or tassels on the tips of the branchlets.

The high development of the organs of transpiration, as shown by the immense number of breathing cells, clearly indicates that forests of the Longleaf Pine, and in fact of most evergreens, are not less important than forests of deciduous trees in influencing atmospheric conditions, particularly when it is considered that in the former, clothed with perpetual foliage, this function suffers but little interruption of its activity.

FLORAL ORGANS.

The male and female flowers are sometimes found on the same branch; they are, however, more frequently situated on different branches, the male flowers mostly on the lower (Pl. V, *b*). The male flowers consist of a slender axis, the staminodial column, around which the numerous naked anthers are densely crowded, forming a cylindrical catkin-like flower from 2 to 2½ inches and over in length, surrounded at the base by a calyx-like involucre consisting of twelve ovate somewhat leathery bracts, of which the lowest pair or exterior ones are laterally compressed, strongly keeled, and much smaller. The connective of the dark-rose purple anthers spreads out in a semiorbicular denticulate crest; a number of these male flowers are crowded around the base of this year's shoot, forming a dense whorl. After the discharge of the pollen the withered flowers remain for several months on the tree. The pollen remaining for a long time suspended in the air is often wafted to widely distant localities. In the latitude of Mobile its discharge takes place during or shortly after the second week of March.

The female flowers (see Pl. V, *a*) are united in a subterminal oval, erect, short-stalked catkin, which is also surrounded by an involucre, the bracts being more numerous, longer, more acuminate, and membranaceous than those of the male flower.

The carpellary scales bearing ovules are oblong oval, tipped with a strong reflexed point, and are almost hidden by the thin flat scales by which they are subtended, which, however, they soon surpass in size. During the first year the young cones make but slow progress in their growth. On the opening of the second season they are scarcely over an inch long; during the summer they increase rapidly and reach their full size during the latter part of the fall. The cones are placed horizontally on the branches below the terminal bud (subterminal), sessile, slender, conical with a slight curve and from 6 to 8 inches long; of a dull tan color; the thick scales are light to dark chestnut brown on the inside, 2 inches or slightly over in length, and bear on their exposed end, or apophysis, a small but prominent tubercle armed with a short recurved prickle (see Pl. VI). Plate VI exhibits truly and fully the open cone and especially the fine markings on the apophysis of the scale. The cones are shed in the latter part of the winter of the second year, rarely remaining to the following spring. On breaking from the branches they leave the lowest rows of the scales behind.

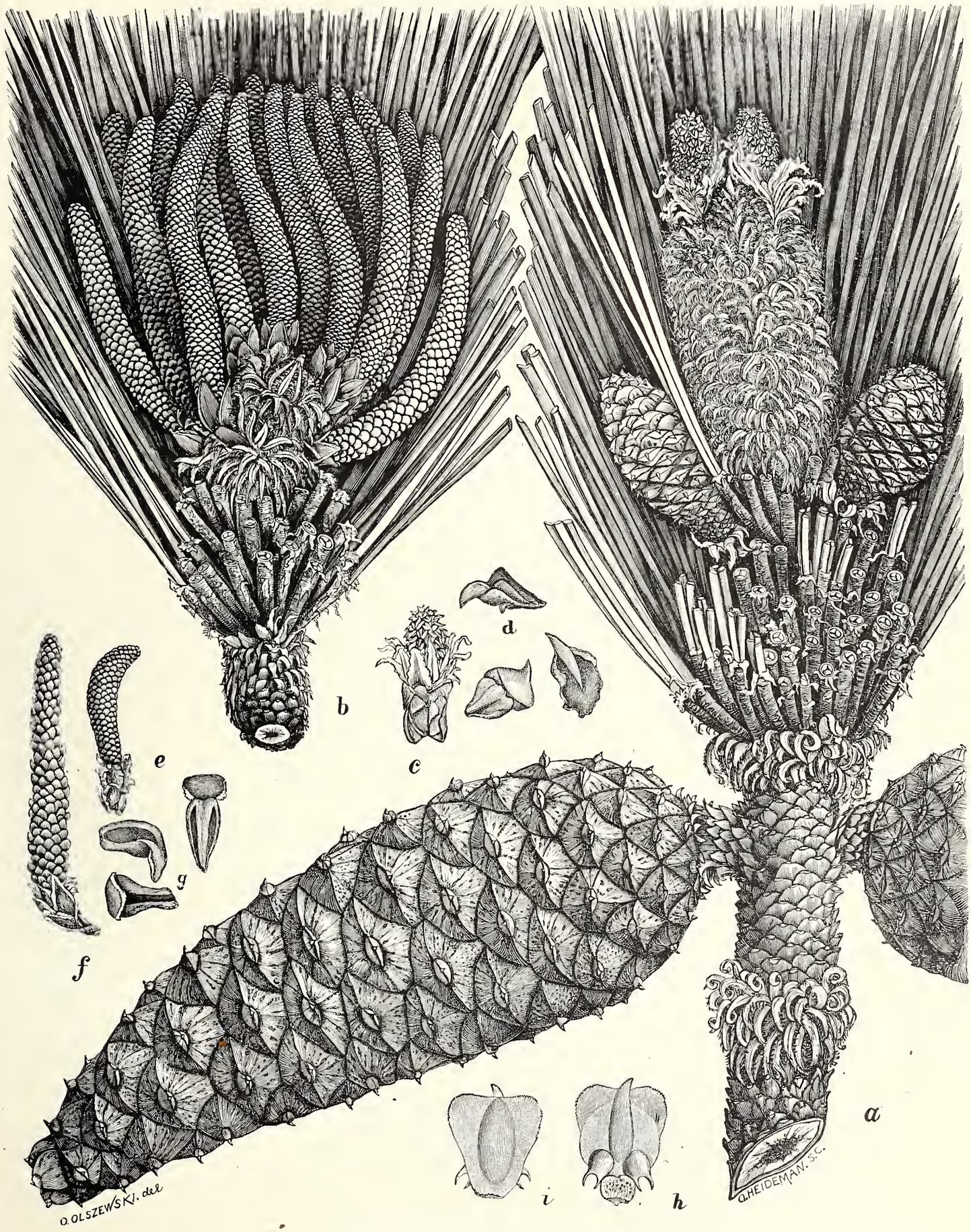
SEEDS.

The seeds are strongly convex, oblong, oval, less than a half inch long, and surrounded by the long oblique wing (see Pl. VI). The shell is whitish, at the front face marked by three prominent ridges, flat, smooth, and darkly spotted on the posterior side. It incloses an oily kernel, covered by a white seed coat; rich in nutritious matter and palatable, the seeds furnish in fruitful years an abundance of mast. They are shed before the fall of the cone during the dry weather, most abundantly during the latter part of the fall (end of October or November the best time for their collection) and in a lesser degree during the winter. They germinate easily after reaching maturity, and it often happens, in wet, sultry weather, that they begin to sprout before leaving the cone, in which event the whole crop is destroyed. This, together with the killing of the flowers by late frosts, seems to be one of the main causes of failure of the seed crop so frequently observed. From the behavior of the seed just mentioned and from its oleaginous character it is to be inferred that the period of time during which the seeds retain the power of germination under ordinary circumstances is but a short one, but as a matter of fact seeds a little over a year old have been known to germinate.

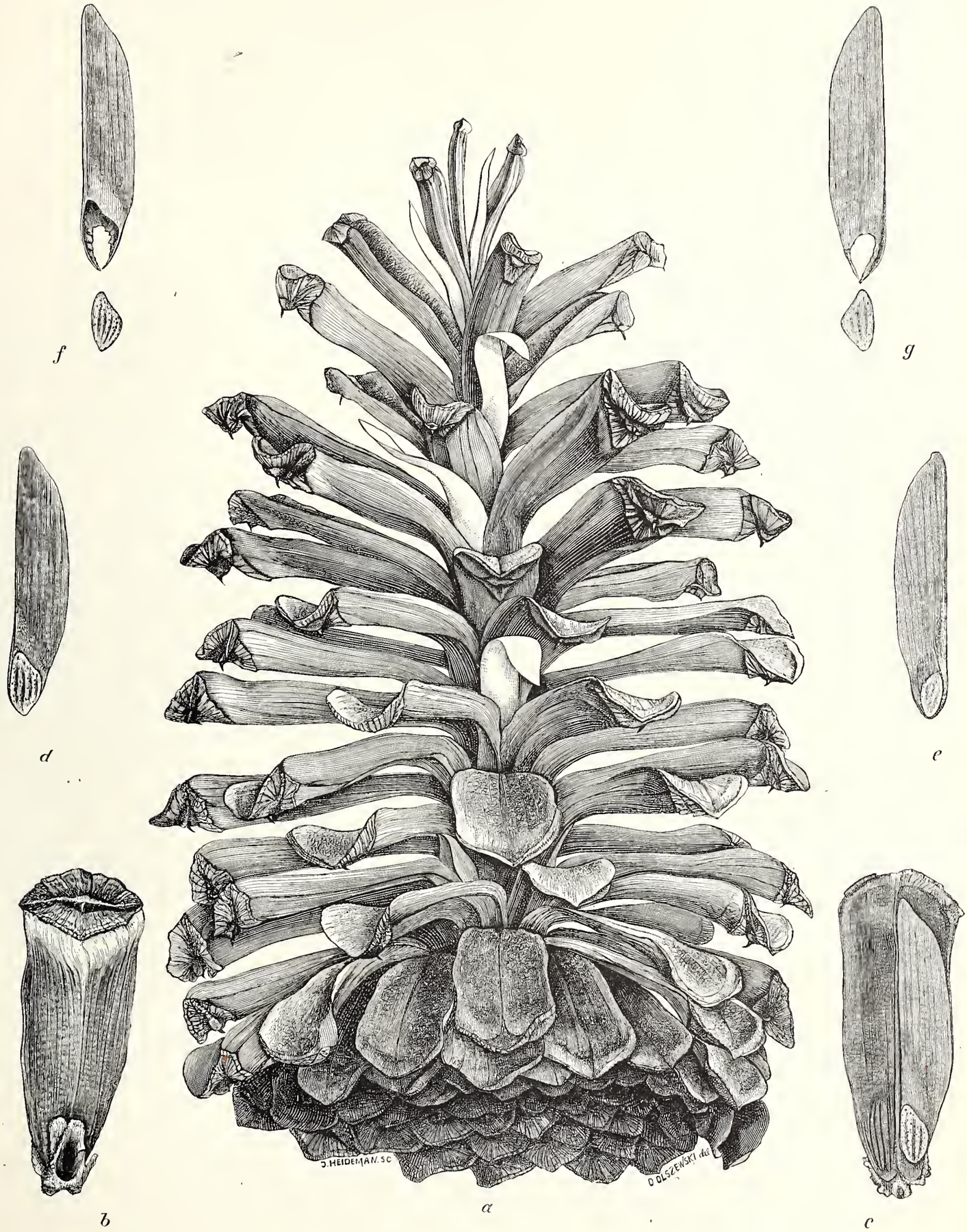
EXPLANATION OF PLATES V AND VI.

PLATE V. Fig. *a*, branch with two female aments (second week of March), at the end of terminal young shoot of the season densely covered with fimbriate silvery bract subtending the leaf buds which are still hidden in their axils; below are two immature cones of one season's growth and mature closed cone of two seasons' growth (October); *b*, branch with the male inflorescence, the leaves cut away to show the dense cluster of male flowers which closely surround the apex of the young shoot; *c*, female ament with basal scales forming the calyx-like involucre; *d*, *d*, *d*, carpellary or seed-bearing scales of female flowers more advanced, lateral, ventral, and dorsal views—magnified 5 diameters; *e*, detached male flower with basal involucral scales, before opening (dehiscence); *f*, male flower, after discharge of the pollen; *g*, three detached anthers, lower sides showing longitudinal slits of the pollen sacs just opening; lateral view of an effete anther; another seen from upper side showing the transverse semilunar crest—all magnified 5 diameters; *h*, detached female flower seen from above; the cuspidate carpellary, or seed scale, bears two strongly bifid naked ovules at its base; *i*, female flower viewed from below, dorsal side; the bract almost covers the carpellary scale, leaving only the tip of the latter and the cusps of the ovules visible; magnified 5 diameters.

PLATE VI. Fig. *a*, mature open cone, after shedding seed; *b*, cone scale seen from lower or dorsal side showing the apophysis with low umbo and small, weak prickle; *c*, cone scale seen from upper or ventral side with seed in place; *d*, seed, upper side; *e*, seed detached from *c*, lower side; *f*, seed detached from wing, upper side, and *g* the same seen from lower side.



PINUS PALUSTRIS: MALE AND FEMALE FLOWERS.



PINUS PALUSTRIS: CONE AND SEED.

THE WOOD.[1]

The wood of the Longleaf Pine is heavier and stronger than that of any other pine offered in the market. The average weight of the kiln-dry wood is about 38 pounds, that of the lumber where the outer lighter portion of the log is largely cut away about 40 pounds, per cubic foot. The kiln-dry wood of the butt weighs about 45 pounds per cubic foot; that of a log 50 to 60 feet from the ground only about 33 pounds, a decrease of weight (and with it of strength) of about 25 per cent. Similarly the wood of inner portions of a log are 15 to 20 per cent heavier than those of the outer portions; or, in other words, the wood laid on when the tree is young is heavier than that laid on when it is old, quite contrary to the common belief which seems to associate the light sapwood color of the young sapling with inferior material. The wood shrinks about 10 per cent of its volume in drying, about 6 to 7 per cent along the rings (tangentially) and 3 to 4 per cent along the radius; seasons easily and without great injury. As in other pines, the greatest amount of water is contained in the sapwood, varying from 30 to 50 per cent of the weight of the fresh wood, while the heartwood contains but about 20 per cent.

In its stiffness and strength the wood is remarkable. The average of a great number of tests indicates for the dry wood of Longleaf Pine an elasticity of 1,540,000 pounds per square inch; strength in cross breaking, 10,900 pounds per square inch; strength in compression, 6,850 pounds per square inch; strength in tension, 15,200 pounds per square inch; strength in shearing, 706 pounds per square inch.

In its structure the wood of the Longleaf Pine resembles that of the other Southern pines. Sapwood and heartwood are well defined; on the fresh cross section the former is light yellowish white, the latter a yellowish brown; drops of limpid resin ooze from every resin duct in the sapwood, the surface of the heartwood remains dry (exceptions only in "lightwood"). The sapwood contains much more water, but is far less resinous than the heartwood. This latter contains 5 to 10 per cent of resin (1 part turpentine to 15 to 20 parts resin), while in the former the resin rarely exceeds 2 per cent. If not kiln-dried, fresh sapwood rapidly "blues" on exposure; heartwood does not, and in general excels the sapwood in durability. On drying, the sapwood shrinks more than the heartwood of the same weight. Contrary to common belief, the wood substance, or cell wall, is not increased in the change from sapwood to heartwood, the walls do not grow thicker, the cavities of the cells do not fill up with foreign matter, nor does the strength of the wood seem to be increased by the change. In general the width of the sapwood is greatest in young and thrifty trees, grows smaller in old and stunted trees, is greatest in the lower parts of the stem and smaller in the top and branches. In old logs the sapwood is made up of from 70 to 100 rings, showing that the wood of any one ring remains in older trees seventy to one hundred years in the sapwood condition before it changes to heartwood. In young trees this period is much shorter, twenty-five to forty years commonly sufficing for thrifty trees at the age of sixty to seventy years, but in stunted individuals it is materially prolonged. The share of the sapwood in the total volume of the stem is always considerable; even in typical old trees of this species it forms 40 per cent and more, while thrifty stems under one hundred years are practically all sapwood.

The annual, or yearly, rings are clearly defined; they are widest near the pith and grow rather uniformly narrower toward the bark. In the inner part a width of one-twelfth of an inch is quite common; the rings near the bark of old logs usually measure less than one twenty-fifth of an inch, often scarcely one-fiftieth of an inch. For old trees the average width for the entire stem may be set at about one-twentieth to one-twenty-fifth of an inch. Each ring consists of two well-marked parts, an inner, softer, whiter part, the springwood, and an outer, harder, and darker portion, the summerwood, so called because formed during the latter part of the growing season.

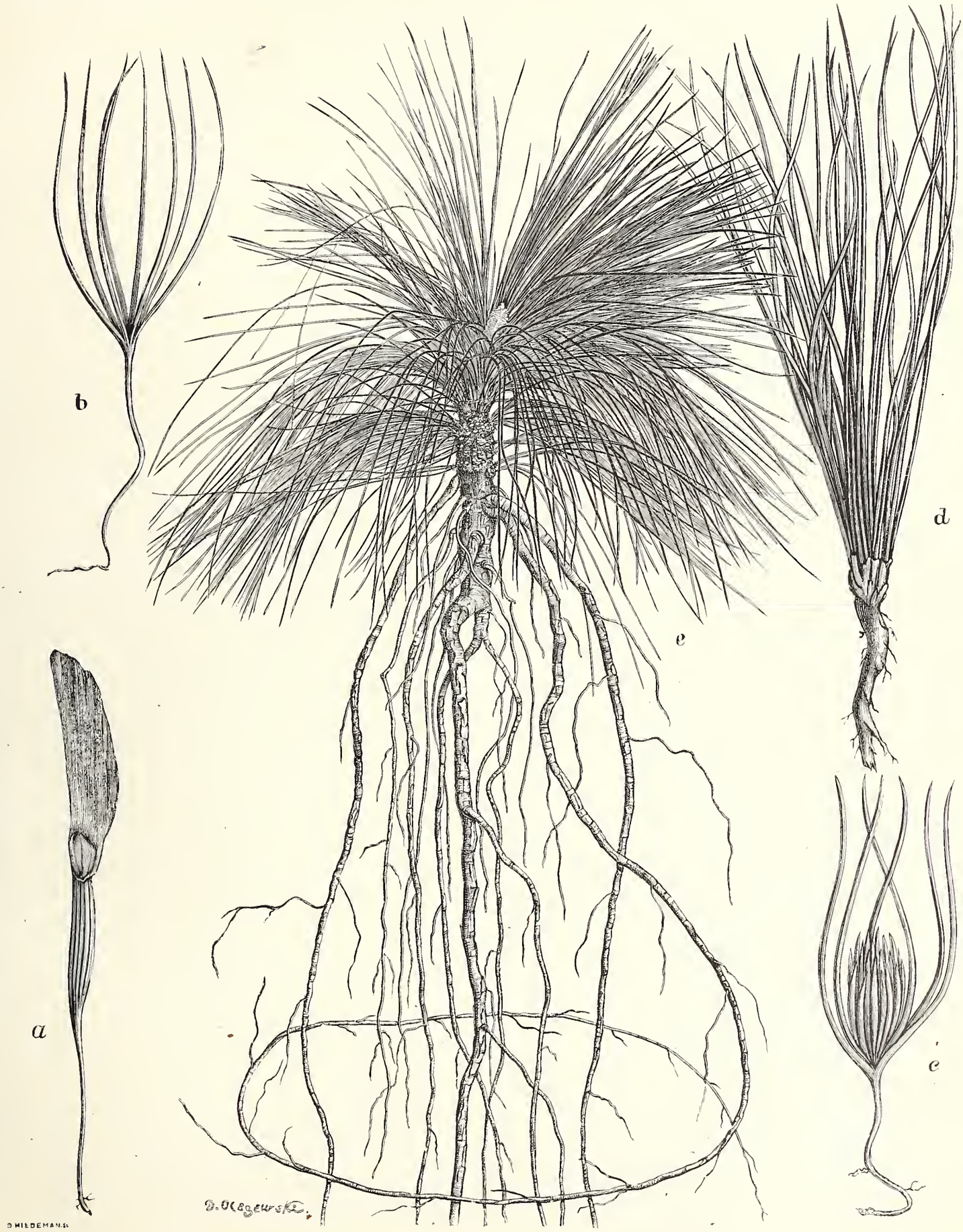
The amount of the summerwood in each ring differs in different parts of the tree. It forms about 45 per cent of the volume of all the wood of the stump, and only about 24 per cent of the wood 60 feet from the butt. It is greater in the heavy inner part of an old log than in the lighter outer portions, and being of a darker color furnishes a convenient means of distinguishing heavy wood. In its finer anatomy (histology) the wood resembles that of the other pines of the *tæda* group. (For the details of structure see the comparative study by Mr. Roth appended to these monographs.)

[1]This statement is furnished by Mr. Filibert Roth, in charge of timber investigations in the Division of Forestry.

EXPLANATION OF PLATE VII.

[Figures natural size, except where otherwise noted.]

Fig. *a*, germinating seed; *b*, young seedling (early spring) with the 8 cotyledons just unfolded; *c*, seedling a few weeks older, showing central cluster of primary leaves just unfolding; *d*, seedling at the end of the first or beginning of the second season, showing bundles of true foliage (secondary) leaves succeeding the primary leaves which have disappeared; *e*, young tree, 3 to 4 years old, with characteristic large root system; one-third natural size.



PINUS PALUSTRIS: SEEDLINGS AND YOUNG PLANT.

GROWTH AND DEVELOPMENT.

In a fruitful year, before the close of the season, with the advent of spring, a dry and sunny state of the atmosphere favoring the fall of the seed, the seedlings are found to come up abundantly in every opening of the forest where the rays of the sun strike the dry ground. The lower (hypocotyledonary) part of the axis of the plantlet is close to the ground, with eight to ten erect colyledons from 1 to 1½ inches in length, their tips inclosed in the shell of the seed, with the long wing persistent and borne banner-like at the top of the plantlet (Pl. VII, *a*). The elongation of the ascending axis proceeds slowly, growth in length being retarded until a certain thickness has been attained, resembling in this respect the growth of the stem of endogenous trees.

Upon examination of a seedling in the latter part of April the cotyledons had disappeared and the caulicle was found to be from one-eighth to one-fourth of an inch long, its length not exceeding its diameter, hidden by a dense tuft of the needle-shaped primary leaves, which closely invest the terminal bud. At this stage a few fascicles of secondary leaves are already showing themselves, still inclosed in their sheaths.

During the first three or four years its energy of growth is mainly expended upon the development of its powerful root system (see Pl. VII, *e*). Before the first spring season has passed, the stout spindle-shaped taproot of the seedling is found to be over 3 inches in length and provided with several fine lateral rootlets, sometimes nearly as long as the main root.

With the opening of June the primary leaves covering the axis are nearly all withered, only a few remaining to the end of the season. With the development of the suppressed secondary axes from which the foliage leaves proceed, the primary leaves are reduced to chaffy fimbriate bracts. Only few of these primary leaves retain the needle-shaped form and green color, namely, those from which no leaf-bearing branchlets were developed. During the first season many of the fascicles of the foliage leaves contain only two leaves, and sheaths inclosing only one leaf are frequently observed.

By the end of the first year the stem of the plantlet is rarely over three-fourths of an inch in length, the main root having attained a length of from 8 to 10 inches.

Having reached the end of the second year the taproot is found from 2 to 3 feet in length, the stem scarcely 1½ inches long, with an increase of diameter hardly perceptible. The conical termination of the spring shoot is now densely covered with the delicately fringed bracts inclosing the buds of the foliage leaves, which impart to it the appearance of a silvery white tuft, by which this species is recognized at first sight.

During the following two years the growth proceeds but slowly, the length by the end of the fourth year averaging not more than 5 inches with a thickness of three-fourths to seven-eighths of an inch. During the same time the taproot is found to gain constantly both in thickness and length (see Pl. VII, *e*). A few single branches now make their appearance on the main axis. The increase of growth from one season to another up to the seventh or eighth year is difficult to follow, since the difference in the appearance of the spring and summer wood cells in the spongy wood of young trees is hardly perceptible, and the rings of annual growth, even as seen in cross sections prepared for microscopical examination, are mostly too indistinct to afford a safe criterion of their age. As far as could be observed the growth proceeds equally slowly during the fifth and sixth years, the plant at the end of that period being from 5 to 7 or 7½ inches in length.

Stage of rapid growth.—With its seventh year the tree may be said to enter on its most vigorous growth. Henceforth the stem (primary axis) increases rapidly in length, and the development of branches (lateral axes) proceeds at an equal rate in regular whorls, to which the symmetry of the tree in that stage of its development is due. During the seventh year, generally, the tree doubles its length, and during a number of successive years the rate of growth in that direction varies between 10 and 20 inches annually, as is clearly shown by the length of the internodes separating the whorls. As the branches increase in length they produce, in the same order mostly, two opposite secondary branches. With the rapid expansion of the leaf surface, the formation of wood keeps pace. The rate of growth in diameter, as well as in height, during this period, is of course variable according to differences in the physical condition of the soil as well as in the available amount of plant food and moisture it contains, and no less upon differences in temperature and of exposure to light and air. These variations are clearly shown

in the annexed tables, exhibiting the rate of growth of the tree during its most active stage. With the increasing accretion of wood the annual rings become sharply defined, leaving no doubt as to the age of the tree.

To make sure as to the relation between the annual rings and the age of the tree, the age of second growth was ascertained by close inquiries directed to settlers who knew the time that had elapsed since this second growth made its appearance in the abandoned fields or in the forest. In every instance it was found that the number of rings accorded closely with the information elicited.

To ascertain the difference in rate of growth and quality of wood between trees grown upon ground once turned by the plow and those sprung up in the original forest on the same soil, several trees of nearly the same size were felled in what clearly appeared to be the remnant of virgin forest, and in a grove grown up in a field abandoned years ago.[1] It was made evident that trees in the original forest required almost double the length of time to attain the same dimension.

A field covered with saplings quite uniform in growth and known to have been thrown out of cultivation during the years 1863 and 1864 afforded a good opportunity for these investigations. A number of trees, varying in diameter between 10½ and 11 inches, and in height between 45 and 50 feet, showed from 30 to 35 rings of growth. The length of the spring shoots on the main stem of these trees was found (June 8) to be from 21 to 24 inches.

In another fine grove, covering a field which was known to have been cultivated for the last time during the years 1835 and 1836, a number of trees were cut down for measurement. The number of rings was found not to exceed 48. These trees also showed great uniformity in size, measuring near the base 11½ to 12 inches in diameter and from 68 to 72 feet in height. The wood was sappy throughout and useless, except for fuel and for making charcoal. For this purpose the land is rented at $4 to $5 per acre. In this grove, ranking as best pine-woods land, the soil of which was nearly level, well drained, and with a light, loamy subsoil, 110 trees of the above dimensions were counted on 1 acre.

Among the trees taken from the forest for determining the difference between forest growth and field trees, one measuring 12 inches in diameter and 76 feet in height showed 85 rings of annual growth, with 9½ inches of heartwood. Two others, 14 and 15 inches in diameter and 70 and 71 feet high, showed 96 rings each. The shoots of the year (June 8) on the primary and lateral axes of these trees were found to be but little over 1 inch in length.

In a third grove, upon poor, sandy, undulating ground, a number of trees below medium size were found cut down to serve for posts and logs. In 25 of these trees the diameter varied between 7¾ and 8 inches, with a nearly uniform height of 60 to 62 feet, the first limb being 18 to 20 feet above the ground. The number of rings varied between 48 and 50. The forests in the same vicinity were stripped of their more valuable timber a number of years before. The largest trees of the original forest growth remaining were from 12 to 15 inches in diameter. Several were brought down for measurement and found to be 73 feet in height by 14 inches in diameter, with 126 rings and 9 inches of heartwood; 73 feet in height by 13 inches in diameter, with 94 rings and 6 inches of heartwood; and 89 feet in height by 14 inches in diameter, with 107 rings and 8 inches of heartwood.

When the tree has reached its second decade it begins to produce flowers and fruit. Having during the course of the following ten to fifteen years reached a length of from 40 to 45 feet, with the main stem clear of limbs, the growth of branches does not proceed with the same regularity; consequently, they are no longer arranged in regular whorls, but appear irregularly, and thus the symmetry of the tree is lost.

[1] On the rolling pine uplands near Spring Hill, Mobile County.

TABLE I.—*Measurements of young trees of Longleaf Pine.*

Number of trees.	Number of rings.	Diameter breast high.	Height.		Locality.	Remarks.
			To crown.	Total.		
		Inches.	*Feet.*	*Feet.*		
1	8	1¾	.....	5 8/12	Springhill, Ala	Opening in forest; pasture protected from fire.
2	9	1⅝	.....	5 4/12	do	Do.
3	10	4½	.....	22	do	Old field; last time plowed in 1874.
4	10	2	.....	8 6/12	do	In the midst of forest.
18	10	2	5	10	Levins Station, La	Opening in forest.
5	11	2¾	.....	11	Springhill, Ala	Deep forest.
6	11	5	.....	23	do	Old field.
319	11	2	6	17	Ridgeland, S. C	Open forest.
7	12	2¾	.....	16	do	Pasture in forest; ground never turned.
19	12	4	9	22	Levins Station, La	Old clearing; turned ground.
8	13	2⅝	.....	15	do	Do.
321	12	2	9	14	Ridgeland, S. C	Opening in forest; sandy uplands.
318	13	4	8	24	do	Do.
9	13	2¾	.....	15	Springhill, Ala	Wood pasture.
10	13	3¾	.....	19	do	Old field.
248	13	4	8	20	Thomasville, Ala	Opening in forest; hills.
317	14	4	7	24	Ridgeland, S. C	Opening in forest; dry uplands.
11	15	5½	.....	35	Springhill, Ala	Field abandoned in 1872.
260	16	2	8	16	Thomasville, Ala	Inclosed forest; hills; under cover.
199	18	2	16	23	Nona, Tex	Flat, damp; opening in forest; exposure free.
198	19	2	12	20	do	Do.
194	20	6	18	47	do	Light swell in open forest; exposure free.
12	20	10	.....	49	Springhill, Ala	Old field; deep soil; abandoned in 1864; from one open grove.
13	21	10	.....	45	do	Do.
14	21	10	.....	50	do	Do.
15	25	11	.....	50	do	Old field; poor, broken ground.
259	22	2	11	21	Thomasville, Ala	Virgin forest; under cover.
246	20	4	14	29	do	Virgin forest; in opening; free.
316	21	6	10	28	Ridgeland, S. C	Open forest; sandy uplands; free.
195	25	7	24	47	Nona, Tex	Flat, damp, dense forest in opening; exposure free.
194	25	4	20	44	do	Do.
196	26	6	17	44	do	Do.
209	36	4	15	35	Ryansville, Calcasieu Parish, La.	Flat, damp; open forest.
210	39	4	17	35	do	Do.
208	40	6	21	50	do	Do.
315	40	8	17	60	Ridgeland, S. C	Boundary field; open.
207	43	6	33	55	Ryansville, La	Flat, damp; open forest.
256	43	6	28	47	Thomasville, Ala	Dense oak opening; oppressed.
258	43	4	34	56	do	In open forest.
16	48	8	.....	60	Springhill, Ala	Old pasture, on poor broken ground.
17–21	52	8	.....	61	do	6 trees from grove of old pasture; yield, sticks and posts for fencing and building; averaging 20 feet in length.
22–25	48	11	.....	73	do	Grove with 115 to 120 trees to the acre; on field abandoned in 1835, and rented to charcoal burners.
22*a*	55	8	.....	58	do	Old pasture.
723	71	5	.....	40	Chunchula, Ala	Old turpentine orchard; bled; exposed for over 20 years, one season after another, to fire.
255	78	6	47	62	Thomasville, Ala	Under cover of forest.
23*a*	80	6	.....	52	Chunchula, Ala	Old turpentine orchard; bled and scorched, exhibiting the effect of bleeding and repeated burning of the woods by their retarded growth.
24*a*	87	8	.....	59	do	Do.
25*a*	95	7	.....	58	do	Do.
26	105	8	.....	56	do	Do.
27	105	8	.....	59	do	Do.

Stage of slow growth.—Rapid as is the increase in length of the primary axis or trunk, amounting during the first half century, in the average, to 14 or 15 inches annually, the rate is subsequently greatly diminished, averaging from the fiftieth to about the one hundred and fifteenth year but from 4 to 5 inches, and from this time to the age of two hundred and fifty years only 1½ inches—that is, at a relative rate of 10, 3, and 1 in the three successive periods. The decrease in the accretion of wood corresponds with the reduction in the growth of the branches and consequent reduction of foliage. From what has been said, it is seen that the Longleaf Pine attains maturity of growth, with the best qualities of its timber, at an age of from one hundred and eighty to two hundred years. After having passed the second century the trees are found frequently to be wind shaken and otherwise defective. The deterioration of the weather-beaten crown lessens the vitality of the tree, and the soil, under prevailing conditions, becomes less and less favorable. In consequence, the trees become liable to disease and mostly fall prey to the attacks of parasitic fungi (red heart). Instances of trees which have reached the maximum age of two hundred and seventy-five or three hundred years are exceptional.

In order to ascertain the age required to furnish merchantable timber of first quality, measurements were made of a number of logs in a log camp in the rolling pine uplands of the lower division of the coastal pine belt near Lumberton, Washington County, Ala. From the results obtained it appears that in this section of the eastern Gulf region, at the lowest figure, two hundred years are requisite to produce logs of the dimensions at present cut at the sawmills.

TABLE II.—*Measurements of Longleaf Pine—period of slower growth from one hundred to two hundred years.*

Number of tree.	Number of rings.	Diameter, clear wood.	Height.		Diameter below crown.	Sap on rudius.	Increase in diameter for each successive half century, in inches.					Number of years required for every inch of wood for each successive half century.					Locality.	Remarks.
			Of timber to first limb.	Total.			1	2	3	4	5	1	2	3	4	5		
		In.	*Ft.*	*Ft.*	*In.*	*In.*												
190	105	19	62	113	11	4											Nona, Tex	Flat; soil, deep sandy loam, damp; virgin forest close; exposure free.
20	110	17	36	92													Wallace, Ala	Gently rolling, pine upland, close; virgin forest; slightly under cover and oppressed.
70	105	9	38	85													Wilson, Ala	Bored timber; abandoned for five years; dry pine, rolling pine forest; exposure free.
	105	14	40	85								5½	6¾				Chunchula, Ala	Open forest; exposure free.
13	110	14	45	78			4½	5¾				11.1	9.5				do	Do.
180	112	15	50	97	11												Levins Station, La.	Do.
191	113	20	53	110	15	4½											Nona, Tex	Flat woods; closed forest; damp, etc.
313	114	12	30	83													Ridgeland, S. C	Clearing in forest; soil dry, sandy.
9	115	12	38	83		3	5½	4½				9.1	11.1				Chunchula, Ala	Rolling pine lands; dry, sandy.
200	115	17	70	96													Noua, Tex	Flat woods; soildamp; crown oppressed.
	116	12½	46	81			5⅛	5				9.7	10				Chunchula, Ala	Rolling pine woods; dry, sandy.
67	116	13	48	87													Wilson, Ala	Bored; dry uplands; open forest; partially free.
253	118	15	45	84	11	2½											Eastman, Ga	Gently rolling uplands, dry; open forest; exposure free.
21	123	17	40	84		2½	6¼	6⅞				7.7	7.8				Chunchula, Ala	Do.
23	125	18	61	102			9	5½				5.5	9.1				Springhill, Ala	Exposed slope; open forest; soil, loamy sand; exposure free.
251	133	18	44	93	13												Eastman, Ga	Open forest; dry, sandy; exposure free.
237	135	17	54	95	10	2½											Reufroe, Ala	Rocky hillside; dry subsoil, loam; exposure free.
252	145	19	49	96	14												do	Rocky hillside; dry subsoil, loam; partially free.
309	145	22	62	102		5											Ridgeland, S. C	Gently undulating open forest; loamy sand; exposure free.
312	140	20	63	99		2½											do	Open pine forest; sandy loam, dry; exposure free.
177	155	23	63	122	16												Levins Station, La.	Do.
24	155	18	65	98			6	5¼	5½			8.3	8.7	9.1			Springhill, Ala	Open pine forest; loamy sand, dry; exposure free.
19	160	24	43	111													Wallace, Ala	Close forest; deep sandy loam; exposure free.
238	165	21	35	97	15												Renfroe, Ala	Rocky hillside; forest open; dry; exposure free.
205	167	16	84	125	8	2											Ryausville, Calcasieu Parish, La.	Flat woods, damp; close forest; exposure free.
239	170	21	50	108	14												do	Do.
178	170	21	62	117	13												Levins Station, Rapides Parish, La.	Rolling open forest; sandy loam; exposure free.
204	180	19	56	102	11												Wallace, Ala	Rolling pine woods; deep sandy loam; partially free.
4	182	19	70	113													do	Rolling pine woods; deep sandy loam; slightly oppressed.
5	183	16	53	111													do	Rolling pine woods; deep sandy loam; partially free.
6	189	19	57	111													do	Rolling pine woods; deep sandy loam; partially under cover.
203	190	21	58	117	11												Ryansville, Calcasieu Parish, La.	Flat woods; loamy, damp; free.

TABLE III.—*Measurements of Longleaf Pine—period of slowest growth from two hundred to two hundred and sixty-six years.*

Number of tree.	Number of rings.	Diameter, clear wood.	Height.		Diameter below crown.	Sap on radius.	Increase in diameter for every half century, in inches.					Number of years required for every inch of wood for each successive half century.					Locality.	Remarks.
			Length of timber.	Total.			1	2	3	4	5	1	2	3	4	5		
		In.	*Ft.*	*Ft.*	*In.*	*In.*												
202	200	23	60	127	14	3½	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Ryansville, Calcasieu Parish, La.	Flat woods; damp soil; sandy, cold loam; exposure free.
5	216	26	55	106	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Wallace, Ala.....	Gently undulating; forest dense; exposure free.
16	202	29	56	108	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Gently undulating; dense forest; loamy sand; exposure free.
241	206	21	54	109	14	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Renfroe, Ala.....	Rocky hills; open forest; exposure free.
189	209	22	61	101	12	1¾	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Nona, Tex	Level, dense forest; damp; exposure free.
18	210	22	50	110	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Renfroe, Ala.....	Rocky hills; forest open; undergrowth dense; exposure free.
240	215	21	50	112	14½	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Wallace, Ala.....	Undulating table-land; forest dense; loamy sand; exposure somewhat oppressed.
5	216	26	55	106	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Undulating table-land; dense forest; exposure free.
61	215	26	64	120	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Wilson, Ala	Undulating table-land; open forest; exposure free; timber bled.
60	220	23	45	117	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Do.
249	235	22	41	108	15	3¼	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Eastman, Ga.....	Undulating table-land; open forest; loamy sand; exposure free.
250	245	27	49	106	21	3¼	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Do.
188	240	25	52	110	17	2½	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Nona, Tex	Level, damp; forest dense; somewhat oppressed.
	250	23	46	102	16	1¾	8	5¼	3¾	2¾	2	6.3	9.5	13.3	18	25	Lumberton, Ala ..	Rolling uplands; forest open; free.
	248	24	40	101	15	2	8¾	6	4½	3½	1½	5.7	8.3	11.1	14.3	33	.....do	Do.
	263	26	50	103	....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Do.
	264	28	45	102	20	....	7½	8¾	4¾	3¼	3	6.6	5.7	12.6	15.5	16.6	.....do	Do.
	264	28	52	103	18	....	7½	8¾	4¾	3	3¼	6.6	5.7	12.6	16.6	12.6	.....do	Do.
	266	26	....	.....	....	....	8	5¾	5¾	3¼	2	6.3	8.7	8.7	15.5	25	.....do	Do.

The following table and diagram (fig. 8) present the average results of a detailed study of over sixty trees collected in different localities. Since only the part of the stem from stump upward is represented, the seedling period of slow growth finds no expression. It will be observed that the growth in height is a maximum between the age of ten and thirty years, amounting to 14 feet for each decade; that it is but half of this at sixty and little over one-third at the age of one hundred years. As plainly indicated in the fine, uniform grain of the wood, the growth in diameter is remarkably uniform until the tree reaches the age of about one hundred years. From this on it decreases rapidly and is scarcely more than one-fourth as great at one hundred and eighty as it is at one hundred. The rate of growth in volume increases steadily up to the one hundredth year, reaching a maximum of over 1.2 cubic feet per year, but decreases, though very slowly, from that time forward, being only about one-half cubic foot per year when the tree reaches the age of one hundred and eighty years.

Rate of growth of Longleaf Pine.

Age.	Diameter with bark (breast high).	Length of timber, with upper diameter of 5 inches.	Height of tree.	Volume.		Periodical accretion.					Average annual accretion.	Current accretion.
				Tree.	Log.	Decade.	Diameter.	Height.	Area of cross sections.	Volume.		
	Inches.	*Feet.*	*Feet.*	*Cu. feet.*	*Cu. feet.*		*Inches.*	*Feet.*	*Sq. foot.*	*Cu. feet.*	*Cu. feet.*	*Cu. feet.*
10	2.0	.....	9	0.12	.....	First.....	1.4	9	0.01	0.12	0.01	0.01
20	3.8	.....	23	1.20	.....	Second.....	1.8	14	.04	1.08	.06	.11
30	5.5	.....	37	3.35	.....	Third.....	1.6	14	.07	2.15	.11	.21
40	7.0	16	48	7.06	5.61	Fourth	1.2	11	.08	3.71	.18	.37
50	8.1	24	56	10.75	9.30	Fifth	1.2	8	.08	3.69	.21	.37
60	9.6	34	62	15.26	13.99	Sixth	1.4	6	.12	4.51	.25	.45
70	11.5	44	67	24.16	23.11	Seventh	1.6	5	.17	8.90	.35	.89
80	13.0	52	72	33.18	32.27	Eighth.....	1.6	5	.19	9.02	.41	.90
90	14.5	56	76	43.57	42.66	Ninth	1.2	4	.16	10.39	.48	1.04
100	16.0	60	80	55.85	54.94	Tenth	1.1	4	.17	12.28	.56	1.23
120	18.0	65	87	76.87	75.87	Eleventh and twelfth.....	1.8	7	.30	21.02	.64	1.05
140	19.5	72	93	96.44	95.49	Thirteenth and fourteenth....	1.6	6	.29	19.62	.69	.98
160	20.5	80	98	112.30	111.50	Fifteenth and sixteenth	.8	5	.16	15.86	.70	.79
180	21.3	85	103	122.00	121.20	Seventeenth and eighteenth ..	.75	5	.12	10.70	.67	.53

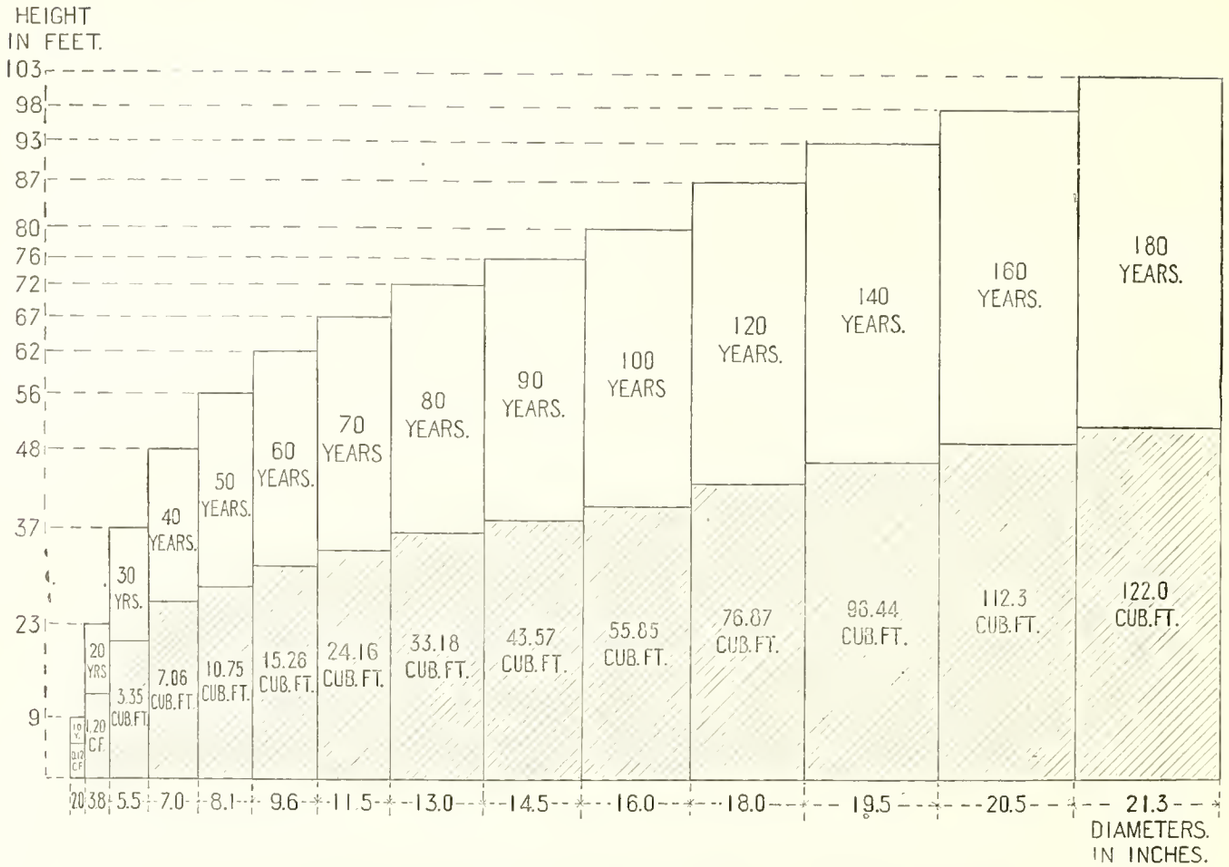


FIG. 8.—Growth of Longleaf Pine: Height, diameter, and cubic contents of average trees at 10, 20, etc., years of age.

CONDITIONS OF DEVELOPMENT.

Demands upon soil and climate.—In its demands upon the soil this pine is to be counted among the most frugal as far as mineral constituents, which are considered as plant food, are concerned, if only the mechanical conditions which influence favorable soil moisture are not wanting. It thrives best on a light siliceous soil, loamy sand or pebbles or light sandy loam, with a slightly clayey subsoil sufficiently porous to insure at least a partial underdrainage and to permit unimpeded development of the long taproot. Whenever the tree meets an obstacle to the development of this root it remains more or less stunted.

The luxuriance of the growth and increase in size of the timber, however, is greatly influenced by the quantity of clay present, particularly in the deep subsoil, which improves mechanical and moisture conditions. This is strikingly exhibited in the timber of the level pine flats west of the Mississippi River, although the surface drainage is almost wanting and the underdrainage through the loamy strata slow, so that the surface of the soil remains damp or water-soaked for the greater part of the year; the stand of timber of first-class dimensions exceeds considerably that of the rolling pine uplands on the Atlantic slope and the lower part of the pine belt in the Eastern Gulf region, which are poorer in clay. Evidently, although the underdrainage is less perfect, the moisture conditions during the dry season of the year, the time of most active growth, must be most favorable. The same fact is apparent in the upper part of the coast pine belt in Alabama and Mississippi, where upon the same area, with a smaller number of trees, the crop of timber may be considered almost twice as heavy as that found on the pine barrens proper farther south. On the soil of fine, closely compacted sand, entirely deficient in drainage as found in the so-called pine meadows along the coast of western Florida, Alabama, and Mississippi, as well as on the siliceous rocky ridges of central and northern Alabama, the tree is so stunted as to be of little or no value for its timber.

"It is neither temperature alone, nor rainfall and moisture conditions of the atmosphere alone, that influence tree growth, but the relation of these two climatic factors, which determines the

amount of transpiration to be performed by the foliage, and again with most species we must place this transpiration movement into relation with available soil moisture, in order to determine what the requirements and the most suitable habitat of the species are" (B. E. Fernow). Hence we find that east of the Mississippi River the Longleaf Pine occurs in greatest frequency along the isotherm of 60° F. ranging to the 34° north latitude, while west of the Mississippi it follows a line between the isotherms of 63° and 64° F. and is scarcely found north of the thirty-second parallel of north latitude. Within this area of its distribution it is exposed to wide variation of temperature and moisture conditions.

Under the influence of the vapor-laden breezes from the Mexican Gulf and an evenly distributed rainfall ranging from 42 to 63 inches during the year, the Longleaf Pine appears of the same thrift and vigor of growth in the interior of Alabama under 34° to 35° north latitude, with the thermometer falling as low as 4° F. (16° C.) and a range of temperature of 93° (at Tuscaloosa), as it is found in the subtropical belt of the coast with a maximum temperature of 105° F. (40° C.) and a range of temperature of 94° west of the Mississippi River, although the temperature reaches rarely a minimum of 15° and 12°, respectively, at the northern limit of the tree in these States, the diminished humidity of the atmosphere and lesser rainfall, particularly during the warmer season, account for its absence. There can be no doubt that the greater exposure to the violence of the sudden gusts of dry and cold wind known in Texas as "dry northers" exercises also no small influence in limiting the Longleaf Pine.

ASSOCIATED SPECIES.

The Longleaf Pine is eminently a gregarious tree, covering areas of wide extent, to the almost complete exclusion of any other species. In the flat woods of the coastal plain, particularly near its northern limit on the Atlantic Slope, it is not infrequently associated with the Loblolly Pine; farther south and along the Gulf Coast to the Mississippi River, more or less frequently with this tree and the Cuban Pine. In the upper part of the maritime pine belt it not rarely occurs together with the Shortleaf Pine and the Loblolly Pine intermixed with the deciduous trees of the uplands, viz, the Black Oak, Spanish Oak, Black-jack, Bitternut, Mockernut Hickories, and Black Gum.

It will be apparent, from what has been said regarding the demands for light, that the associated species must be either slower growers or later comers, if the Longleaf Pine is to survive in the mixture. As has been pointed out elsewhere, with the culling of the Longleaf Pine from the mixed growths it must soon cease to play a part in them, since its renewal under the shade of the remaining associates is impossible.

ENEMIES.

The greatest danger threatening the existence of the forests of Longleaf Pine must be ascribed to the agency of man, since their destruction is caused chiefly by the reckless manner in which they are depleted without heed to recuperation. The right of ownership has been generally acquired on such low terms that since no value has been attached to the land without the timber, despoliation has been carried on with no other object than the quickest return of momentary profits.

EXPLOITATION.

Such management could not but entail tremendous waste, a large percentage of the body of the trees felled being left on the ground to rot or to serve as fuel for the conflagrations which scour these woods almost every year. Infinitely greater than the injuries inflicted upon the forest by the logger and by getting out cross-ties and hewn square timber, which consist chiefly in the accumulation of combustible waste, are those caused by the production of naval stores. When the fact is considered that the production of the 40,000 barrels of spirits of turpentine, which on an average during the latter half of this decade annually reached the market of Mobile alone, implies the devastation of about 70,000 acres of virgin forest, the destruction caused by this industry appears in its full enormity. Under the management of the turpentine orchards prevailing at present, trees of such small size are tapped that they are unable to resist the force of the winds, and in a few years are inevitably prostrated, while the larger trees, weakened by the severe gashes on almost every side, become largely wind-shaken and the timber after a few years almost worthless.

While a judicious tapping is not only justified, but demanded, by an economic system of exploitation, the prevailing methods of orcharding are unnecessarily destructive.

The tapping of sappling timber not yet ripe for the saw, and the destructive fires started in connection with this industry, annihilating all young growth, prevent any renewal of the forest, while the working of large bodies of timber years before milling facilities are available leads often to 20 per cent and more of loss in both quality and quantity of the merchantable product.

FIRES.

The greatest injury to which the pine forests are subject in consequence of turpentine orcharding arises from the fires which are started every spring for the purpose of getting rid of the combustible matter raked from around the tapped trees in order to protect them from accidental conflagrations while they are worked. These forest fires, spreading far beyond their intended limits, destroy entirely the youngest progeny of the pines, stunt the growth of the more advanced trees, and cause the ruin of a large number of older ones in the abandoned turpentine orchards. Burning deeply into the gashes and other exposed surfaces of the tapped trees, these fires hasten their prostration by the gales. Moreover, the fire causes cracks in the surfaces laid bare by the ax and the puller occasions greater exposure to atmospheric action, thus inducing more or less rapid decay. A test, made by sawing through twenty-two logs taken at random from a turpentine orchard after it had been abandoned for a period of sixteen to eighteen years, showed that about one-half of the timber was partially decayed and shaky.

Besides the production of naval stores as a cause of forest fires, there is another scarcely less potent. This is the practice prevailing among the settlers of burning the woods upon the approach of every spring in order to hasten the growth of grass for their famished stock. Fires are also frequently started through the carelessness of loggers and hunters, in the preparation of the ground for tillage, and by sparks from locomotives. These fires, occurring at least once during every year, cause the total destruction of the young growth of the Longleaf Pine. The danger to this species is much greater than to any other Southern wood, because of the greater length of time it requires to reach a size at which it can offer some resistance to fire. In the open forests of Longleaf Pine the fires are not so destructive to the larger timber as in the dense forests of coniferous trees farther north, trees of larger size being, with some exceptions, but slightly, if at all, directly damaged.

Another serious damage, however, resulting from the frequent recurrence of fires is the destruction of all vegetable matter in the soil. Deprived of the mulching needed for the retention of moisture, the naturally porous and dry soil, now rendered absolutely arid and barren, is no longer capable of supporting any larger tree growth or other useful vegetation.

LIVE STOCK.

Of no less danger to the existence of the forests of Longleaf Pine is the injury caused by live stock. This agency, slow in its action, is sure to lead to their destruction unless restricted to some extent. Besides the damage due to the trampling down and mutilation of the young growth by herds of cattle roaming through the woods, the smaller domestic animals—goats and sheep—eat the tufts of the tender foliage of the seedlings, while hogs are seen digging up and chewing the spongy and tender roots of the young plants. As a further agency in the way of the renewal of this species, the destruction of the mature cones might be mentioned, caused principally by the squirrels, which peel off the scales clean to the core in search of the sweet, nutritious seed.

STORMS.

Full-grown trees are frequently uprooted by the hurricanes which from time to time pass through the pine belt. Those having the taproot shortened by impenetrable layers of indurated clay interposed in the subsoil at varying depths are invariably the first victims of the high winds. In trees grown in such places the taproot is found with a tumid and round base as smooth as if polished.

FUNGI.

Frequently full-grown trees are found to show signs of rapid decay. These are recognized by the gradually dying of the smaller limbs and their falling off, in consequence of the rotting of the wood surrounding their base; and after having been cast off a hole or diseased spot remains in the trunk, which is infested by a large fungus of the genus *Polyporus* (punk holes, punk stools). The heartwood of such trees is of a reddish color, soft, sappy, and full of small channels, caused by the breaking down of the walls of the wood cells, filled with the mycelium, the so-called spawn of the fungus, the threads of which also penetrate the medullary rays. Such punky or red-heart timber is found mostly on the ridges in the poorest soil. Apparently superannuated trees are most frequently found afflicted with this rot.

INSECTS.

The Longleaf Pine, throughout its existence, is exposed to the danger of destruction by the ravages of insects, hosts of which, belonging to various orders, are found to infest it from the earliest stages of its development. Upon the tufts of the tender primary leaves of the seedling are often found feeding large numbers of a yellow, black-striped caterpillar, the larvæ of a species of sawfly (*Lophyrus*).

The cambium of trees felled in the latter part of the summer is soon found swarming with the larval brood of bark beetles, which after a short time infest the trees growing near by, causing, as has been again and again observed, the death particularly of the trees of younger growth over extensive areas. Hence the necessity of stopping the practice of felling trees during the summer season. According to information kindly furnished by Mr. Schwarz, of the Entomological Division of the United States Department of Agriculture, most if not all the species of the bark beetles, the family *Tomicidæ* have more than one annual generation, and in the Southern States they have, in all probability, three. The summer generation develops in a very short time, possibly within four or five weeks, and the perfect beetles issuing from the trees felled in August will in September attack the healthy trees near by for want of more suitable food. The ravages spoken of by Michaux refer, no doubt, to these species of *Tomicidæ* beetles which enter the solid wood of trees, e. g., *Gnathotrichus materiarius* and *Xyleborus pubescens*. The galleries of these timber beetles or allied species are found to penetrate the wood to the heart. The grating noise made by the larvæ of the large ceramboid beetle, the *Monohammus*, while engaged in its work of destruction frequently strikes the ear in the forest. That there is a large number of species belonging to different orders preying on the Longleaf Pine and more or less destructive to the life of this tree is apparent from the following communication from Mr. Schwarz:

The number of insects to be found on the Longleaf Pine is very large and comprises species of most orders, but a complete list of them has never been published and the habits of most of them have never been carefully studied. Only those which are really injurious to the tree need to be considered.

Order *Hymenoptera:* Several species of sawflies (*Tenthredinidæ*), occasionally very injurious to the younger trees, the larvæ defoliating the branches. The species thus far observed are *Lophyrus Abbotii*, Leach; *Lophyrus Lecontei*, Fitch, and three or four less common species.

Order *Coleoptera*, slip B: Round-headed borers (larvæ of *Cerambycidæ*) affect the trees similarly to the *Buprestidæ*, but their burrows are always cylindrical, and some species bore only under the bark. The most abundant and destructive is *Monohammus titillator*, Fabr., but there are many other species, of which the following is a partial list: *Scaphinus sohæricollis*, Lec.; *Ascmum moestum*, Hald.; *Criocephalus nubilus*, Lec.; *Eupogonius tomentosus*, Hald.; *Acanthocinus nodosus*, Fabr. In the family *Curculionidæ*, the worst enemy of the pine tree in the more Northern States, *Pissodes strobi* is rare in the region of the Longleaf Pine, but another species, *Pachylobius picivorus*, Germ., the larvæ of which bore under the bark, is quite common and greatly injurious to the Longleaf Pine. Of its more dangerous enemies the Scolytid beetles, which mostly bore their galleries under the bark, only a few species entering the solid wood, the following are known to infest *Pinus palustris: Pityophthorus pulcarius*, Zim.; *P. annectens*, Lec.; *Tomicus calligraphus*, Ger.; *T. avulsus*, Eich.; *T. cacographus*, Lec.; *Crypturgus atomus*, Lec.; *Dendroctonus terebrans*, Oliv.; *D. frontalis*, Zim.; *Hylastes porculus*, Er.; *H. exilis*, Chap.

The few species entering the solid wood are *Platypus quadridentatus*, Oliv.; *Gnathotrichus materiarius*, Fitch, and *Xyloborus pubescens*, Zim. Most of these Scolytidæ are extremely numerous in specimens, and although they usually infest injured or diseased trees, yet in cases of excessive multiplication or for want of proper food they often attack healthy trees, which within one or two years succumb to their attacks.

NATURAL REPRODUCTION.

Certain peculiarities inherent to this species form a series of obstacles in the way of its spontaneous reproduction. These are, first, the rare occurrence of seasons of abundant crops of seed, and, second, its slow growth during the earliest part of its development, rendering the young offspring of this pine liable to be suppressed by competing species of quicker growth. To these causes is to be further added its dependence upon the influence of direct sunlight, which is required for its germination as well as during the subsequent stages of its growth to maturity, and the sensitiveness of the seeds and seedlings to moisture; placed in a wet, undrained soil, the germinating power of the first is destroyed and the latter will perish on exposure to the same conditions. A study of the young growth of the Longleaf Pine over the different regions of its habitat leads unavoidably to the conclusion that the chances for the reproduction of its forests, left to the ordinary course of nature, are quite limited, even if the adverse conditions arising from human agencies are left out of consideration. On the lowlands of the Atlantic Coast toward its northern limit this pine is almost invariably replaced by the Loblolly Pine, while farther south and in the coastal plain of the Gulf States east of the Mississippi River, after its removal, it is replaced partly by the Loblolly Pine and largely by the Cuban Pine. On the wide expanse of uplands rising above the coastal plain with their broad ridges of a soil of sandy loam, the young trees of the Longleaf Pine are met with in every stage of growth. Attaining, however, during the first five or six years scarcely a greater height than the surrounding herbage, the seedlings are irredeemably ruined by the various destructive agencies to which they are exposed. On land liable to repeated conflagrations, a scrubby growth, chiefly of barren oak and other upland oaks already mentioned, takes possession and excludes by its shade the pine. If upon the rolling pine lands or dry pine barrens the removal of most of the original tree covering is followed by a succession of barren years, the ground will surely be invaded by the hard-wood trees mentioned, which will retain possession. Under the shade of these trees the Longleaf Pine can never again find a home. In the stronger soil of the upper division of the maritime pine belt, the region of mixed growth, where the seedlings of the Longleaf Pine spring up simultaneously with the hard wood trees and the seedlings of the Shortleaf Pine, these latter will eventually gain the supremacy and suppress those of the Longleaf Pine; consequently the latter is seldom observed in mixed forests of second growth. In the flat woods, particularly in the pine flats of southwestern Louisiana and Texas, with a soil water-soaked during the winter and spring, the offspring of the Longleaf Pine is still more rarely met with for the reasons stated. From these facts it is evident that, owing to natural causes, combined with the unrestricted sway of the influences leading to its destruction by human agency, the offspring of the Longleaf Pine is rarely seen to occupy the place of the parent tree, even in the region most favorable to its natural renewal, and that final extinction of the forests of the Longleaf Pine is inevitable unless proper forest management is applied.

FOREST MANAGEMENT.

The time for the acquisition of timber lands or of the right of working them for their products at prices far below what could be considered as an adequate return for their instrinsic value has well-nigh passed away. The opportunities which existed during the last twenty-five years for acquiring Longleaf Pine lands, which were open to purchase by the hundreds of thousands of acres have now in a great measure ceased to exist. The greater part of this kind of property has passed into the possession of capitalists, and the rest will soon be similarly controlled. Under this new order of things the price of these timber lands is gradually approaching figures more in proportion to their true value. The depredations committed unblushingly on the public lands, and on the lands of railroad corporations and private owners, are rendered less easy every year under a mutual protection of interest. Reckless waste and devastation, heedless of the interests in the future, are giving way to a more economical management of the timber resources in the logging camp and in the mill. No measures have been attempted to maintain these resources by sparing the younger timber in its best stage of growth from the ax, or to provide in any other way for the protection and preservation of the younger growth.

What has been said of the geographical distribution of this tree and its demands upon climate, soil, and exposure, demonstrates that east of the Mississippi River it can be successfully grown all over the maritime plain of the Southern States (Austro-riparian zone) and in the interior of Alabama, through a large region of the Carolinian and the extreme southern extension of the Appalachian zone to an elevation above the sea falling little short of 1,000 feet. And the sandy soils of this region, largely too poor for agricultural use, are par excellence Longleaf pinelands. In the renewal of the forests of Longleaf Pine, upon areas denuded, the fact must be borne in mind that to produce timber which is under present conditions considered of fair merchantable quality a period of not less than one hundred and fifty years is required, and that to produce timber of the strength, clearness, and durability for which it is held in such high esteem the slow growth under the severe and hardening conditions involved in the struggle for light in the crowded forests is necessary. Hence, economic reasons would point to the maintenance and conservative management of the existing forests of Longleaf Pine and their renewal by natural reproduction, and perhaps best the method of selection which under the present conditions appears the most practicable, involving chiefly methods of protection.

By this method all or most of the mature trees, corresponding in their proportions to the most desirable quality of timber, are cut and the rest left to grow till they reach similar dimensions, to be in their turn replaced by the second growth, which in the openings from time to time springs up. In fact, this method was followed in the earlier days of the timber industry in the several regions of the Longleaf Pine, where the forests were being culled for the best sizes at intervals of from fifteen to thirty years. But owing to the exhaustion of the mature pine from forests within distance of railroad lines and water courses, which necessitates great outlays of capital for constructing tramroads or waterways, the original practice of selection has been abandoned, no tree being spared at present that will make a stick of timber, however small, as long as it finds a sale in the market. Care should of course be taken to leave always enough seed trees evenly distributed, and the chief care is to be directed to the protection of the seedlings and other young growth from the destructive agencies mentioned—fire, cattle, and the encroachment of invading species. A forest under such management would necessarily present a great diversity in the growth of the trees, and the length of time between one cutting and the next would be equally variable. It must be remarked that the demand of this species for the unhindered access of direct sunlight during the time of germination and successive stages of growth might prove a serious obstacle to the continued success of this method of selection; and the "group method," as described in the report of the chief of the Division of Forestry for 1894, might be substituted with advantage. Where it is desired to reestablish the growth of Longleaf Pine upon denuded areas, the ground must be cleared of every obstacle in the way of free access of the rays of the sun before the sowing. Owing to the ease with which the seeds germinate and the seedlings take root in the ground, but slight preparation of the same would be required, and there would be no difficulty in procuring a good stand. If transplanting is to be resorted to, the seedlings should be taken up during the fall or winter succeeding the first season of their growth, before the further development of the rapidly growing taproot, the precaution always being taken to prevent any injury to the rootlets and their drying out before their transfer to the ground. Since the trees clear themselves easily of branches, the stand in the plantation in the earlier stages does not need to be as dense as with other species. In order to secure improvement and permanency of favorable soil conditions, the litter from the shedding of the leaves and gradual decay of herbage should be left undisturbed on the ground.

There can be hardly any doubt that the introduction of other shady species would greatly assist in improving soil conditions and producing more rapid development of the pine. Care would have to be taken to bring in these species later, say between fifteen and twenty years, when the pine has begun to make its rapid height growth and can escape the shade of its neighbors.

For the present, however, the economic conditions are hardly yet ripe for any artificial reforestation, but the great importance of this valuable forest resource to the industrial and commercial development and prosperity of the people living within its limits should be apparent enough to keep them at least from preventing its natural reproduction. The growth of the young timber after the first few years is rapid enough, as may be seen from the table on page 57, and

after fifteen or twenty years, when the trees have reached a diameter of 12 inches, they can be tapped for resin and will give a continuous revenue. Under careful management, and by tapping only the trees which should be removed in thinnings to make light for the rest, this revenue can be obtained without in any way impairing the final harvest value.

CONCLUSION.

From the southern frontier of Virginia, throughout the lower part of the Southern States, to the limits of high and compact forest growth west of the Mississippi River, spread over an area of from 90,000 to 100,000 square miles, the forests of the Longleaf Pine present yet a stupendous timber wealth. Yet, if we deduct the farm lands, and consider that large areas have been culled or entirely denuded of the original growth, we may estimate that the amount of timber standing can at best not exceed 100,000,000,000 feet, and is probably much less, while the cut, which at present does not fall short of 3,700,000,000 feet, board measure, is bound, as the Northern pine is giving out, to increase at even greater rate than in the past. Under such a strain, outstripping by far the possibilities of their reproduction, the exhaustion of the resources of these forests within the near future is inevitable, and if the devastation under present management by the naval store industry and the destruction caused by fire and domestic animals is continued their extermination as far as practical purposes are concerned must be regarded as equally certain.

APPENDIX.

THE NAVAL STORE INDUSTRY.

The resinous product of the Longleaf Pine furnishes the raw material for the production of naval stores, one of the most important industries in connection with the resources of the American forests. At present the bulk of these stores used in the world is derived from the forests of Longleaf Pine, and hence this industry is almost entirely confined to the coast pine belt of the Southern States, the proportion contributed by France, Austria, and other countries being insignificant.

For the year 1892 the foreign export of spirits of turpentine alone amounted to over 260,000 casks and the total production exceeded 350,000 casks. To produce this amount of spirits at least 2,500,000 acres must have been in orchard, and since over one-third of the total production is furnished by orchards being worked for the first year, over 800,000 acres of virgin forest must be attacked annually to supply present demands.

Under the name of naval stores are comprised the products derived directly or indirectly from the resinous exudation of cone-bearing trees, mostly pines, including tar, the product of the destructive distillation of the wood of pines highly charged with resinous matter. The name is undoubtedly derived from their extensive consumption in the shipyards and on board of vessels. These products are:

RESIN, OR CRUDE TURPENTINE.

The resin of the Longleaf Pine recently exuded is almost colorless, or of a pale straw color, of the consistency of honey, having a terebinthinous odor and taste, and like all substances of the same class is insoluble in water, but soluble in alcohol, ether, and spirits of turpentine. It consists of a volatile oil and a solid resin held in solution partially suspended in the former. The best quality is obtained during the first year the tree is worked, known as "virgin dip" or "soft white gum," which is almost colorless and contains the largest quantity of volatile oil. In the following year it is of a deeper yellowish color, the "yellow dip," which with each succeeding year becomes darker in color, more viscid, and poorer in volatile oil.[1]

The resin toward the close of the season produced on the tree under the influence of a cooler temperature is called hard gum, or scrape. This solidified resin of whitish to yellowish color contains only half of the quantity of the spirits of turpentine obtained from the dip or soft gum. By the distillation of the crude turpentine the naval stores of most importance to trade are obtained.

SPIRITS OF TURPENTINE, OR OIL OF TURPENTINE.

Spirits of turpentine, or oil of turpentine, is the volatile constituent of the resin. This liquid when freshly prepared is colorless, of a peculiar odor and taste, of a density varying between 0.85 and 0.87, volatile at ordinary temperatures, boiling between 304° and 320° F. It turns polarized light to the right, a characteristic feature of the American spirits of turpentine, most of the spirits from other sources polarizing the light to the left. In its pure state this volatile oil is free from oxygen, being a hydrocarbon of the composition of $C_{10}H_{16}$. It is highly inflammable and

[1] It is still an open question whether this deterioration is necessary or only owing to faulty manipulation. Experiments to settle this question are now in progress in the Forestry Division.

burns with a sooty flame. It is a good solvent for many resins, wax, fats, caoutchouc, sulphur, and phosphorus, and is used in the arts and industries for the preparation of varnishes, in paints, the rubber industry, etc. Before the introduction of kerosene oil it was used extensively for an illuminator; it is also used in medicine internally and externally and often as an adulterant of various essential oils.

ROSIN, OR COLOPHONY.

The solid constituent of the crude turpentine which forms the residue remaining after its distillation. It is of different degrees of heaviness, according to the quantities of volatile oil retained after distillation, is brittle, easily powdered, of a glassy luster, and of the specific gravity of 1.07, almost without taste, of a faint terebinthinous odor. It becomes soft at about 176° F., melts between 194° and 212° F., and is soluble in the same solvents as crude resin. According to the nature of the crude turpentine, depending upon the number of seasons the trees have been worked, it shows different properties in regard to the transmission of light, and in color. It is either perfectly transparent, translucent, or almost opaque and almost colorless, or a pale straw color to golden yellow, reddish yellow, through all shades to dark brown and almost black. The market value of this article is entirely regulated by these properties. In the American market the following grades are distinguished: WW (Water White) and WG (Window Glass), the lightest and highest-priced grades, obtained from the "virgin dip;" N (Extra Pale), M (Pale), K (Low Pale), I (Good No. 1), H (No. 1), F (Good No. 2), E (No. 2), D (Good Strain), C (Strain), B (Common Strain), and A (Black).

PINE TAR.

This is not exactly a by-product of the turpentine orchard, but is produced by the destructive distillation of the wood itself. It is chiefly produced in North Carolina, where this industry has been carried on since the earliest colonial times. Small quantities are produced in other sections of the Southern pine belt, mostly for home consumption. Perfectly dry wood of the Longleaf Pine, dead limbs and trunks seasoned on the stump, from which the sapwood has rotted, are cut in suitable billets, piled into a conical stack, in a circular pit, lined with clay, the center communicating by a depressed channel with a receptacle—a hole in the ground—at a distance of 3 to 4 feet from the pile. The pile is covered with sod and earth, and otherwise treated and managed like a charcoal pit, being fired from apertures at the base, giving only enough draft to maintain slow smoldering combustion. After the ninth day the tar begins to flow and continues for several weeks. It is dipped from the pit into barrels of 320 pounds, the standard weight. One cord of dry "fat" or "lightwood" furnishes from 40 to 50 gallons of tar. The price of pine tar is quoted as low as $1.05 a barrel. Since considerable quantities of tar are produced incidentally in the destructive distillation of wood in iron retorts for charcoal and other products, the price has been greatly depressed.

COMMON PITCH.

The best quality is obtained by boiling down tar until it has lost about one-third or more of its weight. The naval pitch of commerce has more or less rosin of the lowest grade added to it. Pitch is also obtained as the residue remaining from the dry distillation of rosin for rosin oil.

HISTORICAL REMARKS.

The tapping of the trees for the crude turpentine and the manufacture of tar and pitch was first resorted to by the earliest settlers of North Carolina, and in later colonial times these products furnished the largest part of the exports of the colony. In the three years from 1768 to 1770 the exports of crude turpentine, tar, and pitch represented on the average for each year a value of $215,000 of our present currency. Most of the crude turpentine was shipped to England. Later the distillation of spirits of turpentine was carried on in clumsy iron retorts in North Carolina and in Northern cities. The introduction of the copper still in 1834 resulted in a largely increased yield of spirits of turpentine, and the industry received a great impetus. With the new demand for spirits of turpentine in the manufacture of rubber goods, and its increased use as an illuminator, the number of stills increased greatly, and turpentine orcharding was rapidly extended south and west beyond its original limit. The large consumption of spirits of turpentine

Fig. 1.—Chipping the Longleaf Pine.

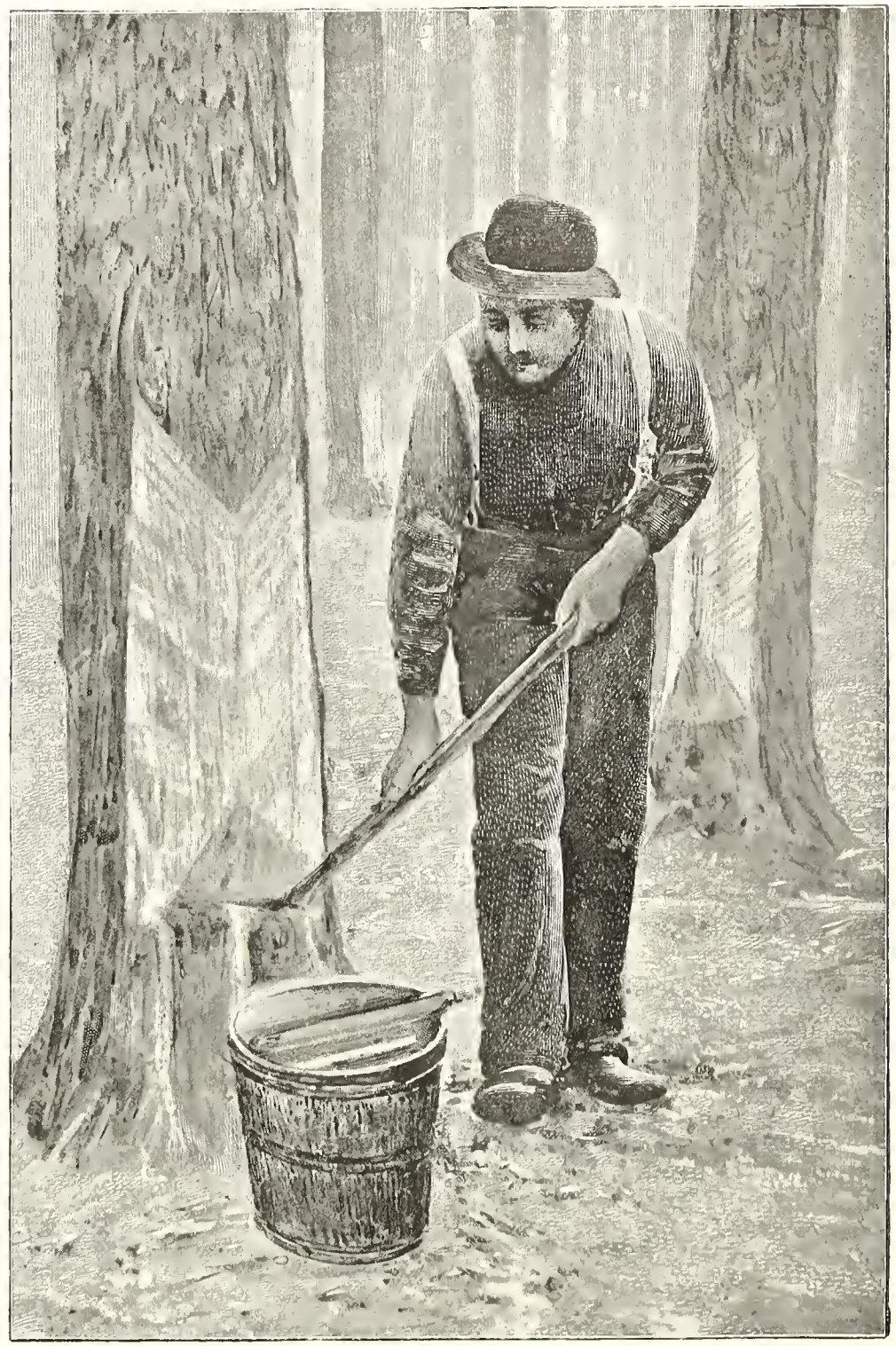


Fig. 2.—Dipping the Crude Resin.

Turpentine Orcharding in Louisiana.

caused such an increase in its production that the residuary product, rosin, became largely in excess of the demand, and, in consequence, much depreciated. This reduction of profits in the business caused the transfer of the stills from the leading markets to the source of the raw material, the forest. From that time, 1844, dates the great progress made in the extension of this industry. Up to that time more than half of the crude turpentine was distilled in North Carolina, but thenceforth the industry spread into the States of South Carolina, Georgia, Florida, and the Gulf States to the Mississippi River.

At the close of the war the demand for spirits of turpentine was not so great as before, petroleum products of several kinds having been found to take its place not only for illuminating, but also for other purposes. With the general extension of arts and manufactures all over the world, there has since been an increasing demand for spirits of turpentine and rosin. The exports of these articles in the year 1890 amounted to $8,135,339 in value.

TURPENTINE ORCHARDING IN THE FORESTS OF LONGLEAF PINE.

In the establishment of a turpentine orchard and a still, two points must be considered, namely, proper facilities of transportation to shipping points and a sufficient supply of water for the condenser connected with the still. The copper stills generally in use have a capacity of about 800 gallons, or a charge of 20 to 25 barrels of crude turpentine. For such a still to be charged twice in twenty-four hours during the working season, 4,000 acres of pine land of a good average stand of timber are required. This area is divided into twenty parcels each of 10,000 boxes, as the receptacles are called, which are cut into the tree to receive the exuding resin. Such a parcel is termed a crop, constituting the allotment to one laborer for the task of chipping. The work in a turpentine orchard is started in the earlier part of the winter with the cutting of the boxes. Until some years past no trees were boxed of a diameter less than 14 inches; of late, however, saplings under 10 inches in diameter are boxed. Trees of full growth, according to their circumference, receive from two to four boxes, so that the 10,000 boxes are distributed among 4,000 to 5,000 trees on an area of 200 acres.

The boxes are cut (see Pl. VIII) from 8 to 12 inches above the base of the tree, 7 inches deep and slanting from the outside to the interior, with an angle of about 35°. In the adult trees they are 14 inches in greatest diameter and 4 inches in greatest width, of a capacity of about 3 pints. The cut above this reservoir forms a gash of the same depth and about 7 inches of greatest height. In the meantime the ground is laid bare around the tree for a distance of 2½ to 3 feet, and all combustible material loose on the ground is raked in heaps to be burned, in order to protect the trees against danger of catching fire during the conflagrations which are frequently started in the pine forests by design or carelessness. The employment of fire for the protection of the turpentine orchard against the same destructive agency necessarily involves the total destruction of the smaller tree growth, and if left to spread without control beyond the proper limit, often carries ruin to the adjoining forests.

During the first days of spring the turpentine begins to flow and chipping is begun, as the work of scarification is termed, by which the surface of the tree above the box is laid bare beyond the youngest layers of the wood to a depth of about an inch from the outside of the bark. The removal of the bark and of the outermost layers of the wood—the "chipping" or "hacking"—is done with a peculiar tool, the "hacker" (fig. 9, *e*, *f*), a strong knife with a curved edge, fastened to the end of a handle bearing on its lower end an iron ball about 4 pounds in weight, to give increased force to the stroke inflicted on the tree, and thus to lighten the labor of chipping. As soon as the scarified surface ceases to discharge turpentine freely, fresh incisions are made with the hacker. The chipping is repeated every week from March to October or November, extending generally over thirty-two weeks, and the height of the chip is increased about 1½ to 2 inches every month. The resin accumulated in the boxes is dipped into a pail by a flat trowel-shaped dipper (fig. 9, *a*) and then transferred to a barrel for transportation to the still. In the first season from six to eight dippings are made. The 10,000 boxes yield at each dip 40 barrels of "dip" or "soft gum," as it is reckoned in Alabama, to be of 240 pounds net weight. The flow is most copious during the height of the summer (July and August), diminishes with the advent of the cooler season, and ceases in October or November. As soon as the exudation of the resin is arrested and

the resin begins to harden under the influenee of a lower temperature it is earefully seraped from the searified surfaee and the boxes with a narrow, keen-edged knife attaehed to a long wooden handle (fig. 9, *b*, *c*). In the first season the average yield of dip amounts to 280 barrels and of the hard gum or serape to 70 barrels. The first yields 6½ gallons spirits of turpentine to the barrel of 240 pounds net, and the latter 31 pounds to the barrel, resulting in the produetion of 2,100 gallons spirits of turpentine and 260 pounds of rosin of higher and highest grades. The dippings of the first season are called "virgin dip," from which the finest quality of rosin is obtained, graded in the market as Water White (WW) and Window Glass (WG). In the second year from five to six dippings are made, the crop averaging 225 barrels of soft turpentine and 120 barrels of scrape, making altogether about 1,900 gallons spirits of turpentine.

The rosin, of whieh about 200 barrels are produeed, is of a lighter or deeper amber color, and perfeetly transparent, of medium quality graded as I, H, and G. In the third and fourth years the number of dippings is reduced to three. With the flow over a more extended surfaee, the turpentine thiekens under prolonged exposure to the air and loses some of its volatile oil, partly by evaporation and partly by oxidation. In the third season the dip amounts to about 120

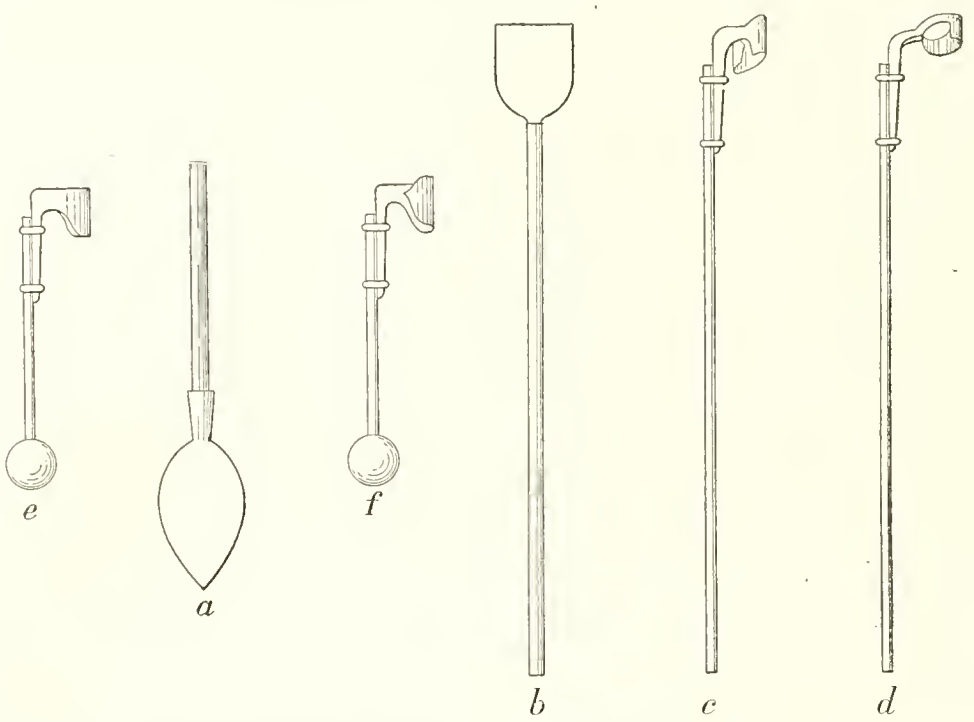


FIG. 9.—Tools used in turpentine orcharding: *a*, dipper; *b*, pusher; *c*, open puller; *d*, closed puller; *e*, *f*, hacker (front and rear view).

barrels and the scrape to about 100 barrels, yielding about 1,100 gallons spirits of turpentine and 100 barrels of rosin of a more or less dark eolor, less transparent, and graded as F, E, and D. In the fourth and last year three dippings of a somewhat smaller quantity of soft turpentine than that obtained the season before and 100 barrels of serape are obtained, with a yield searcely realizing 300 gallons of spirits of turpentine and 100 barrels of rosin of lowest quality, elassed as C, B, and A. After the fourth year the turpentine orehard is generally abandoned. Owing to the reduetion in quantity and quality of the raw produet, it is not eonsidered profitable by the larger operators to work the trees for a longer time. It is only in North Carolina that the smaller landowners work their trees for ten or more sueeessive seasons, protect the trees against fire, and after giving them rest for a series of years, apply new boxes on spaees left between the old ehips—"reboxing."

DISTILLATION.

The proeess of distillation is earried on in the ordinary way, and requires eare and experience to obtain largest quantities of rosin of highest grade and to guard against overheating. After heating the still, somewhat above the melting of the crude turpentine, a small stream of tepid water from the top of the eondenser is eonducted into the still and allowed to run until the end of the proeess. A large quantity of water runs over with the spirits of turpentine, whieh is

collected in a barrel, where it separates from the water and is then immediately transferred into barrels. After the oil has ceased to run freely the heating of the still and the influx of water has to be carefully regulated. After all the spirits of turpentine has been distilled over, the fire is removed and the contents of the still are drawn off by a tap connected with the bottom. This residuum, molten rosin, is at first allowed to run through a wire cloth and is immediately strained again through coarse cotton cloth or cotton batting, made for the purpose, into a large trough, from which it is ladled into barrels. The legal standard weight of the commercial package is 280 pounds gross. A turpentine distillery on the basis of twenty crops produces on the average during the four years that the boxes are worked 2,400 casks or 120,000 gallons of spirits of turpentine and about 12,000 barrels of rosin or 2,800,000 pounds, the lowest grades, B and A, excluded, a total value of about $60,000 at average prices. The prices of spirits vary at present from 28 to 40 cents a gallon, even through the same season, according to supply and demand in the market. The average quotations on December 30, 1892, at Wilmington were 28 cents for spirits and $1.91 for a barrel of rosin down to grade C.

COST OF ESTABLISHING A PLANT AND WORKING THE CROPS.

Timber lands with the privilege of boxing the timber for a term of four years are rented at the rate of $50 per crop of 10,000 boxes, or 200 acres. The establishment of a plant for the working of twenty crops, or 4,000 acres of timber land, requires an investment of about $5,000, including the buildings, stills, machinery for pumping water, tools, and teams. According to the statements of an experienced operator, the cost of working the trees of one crop during the four years, which is mostly done by the job—that is, the making and cornering of the boxes, inspecting the same, raking around the trees, chipping, dipping, scraping, hauling the crude turpentine to the still, including cost of barrels for spirits of turpentine, and for the rosin and superintending the crop—amounts to about $2,300 per crop, or $46,000 for the twenty crops. If to this amount the interest, 6 per cent per annum, on the capital invested and the depreciation in the value of the plant during the four years is added, with some other incidental expenses (taxes, etc.), the cost of the production of the 120,000 gallons of spirits of turpentine and 12,000 barrels of merchantable rosin foots up to not less than $50,000.

FIG. 10.—Improved method of turpentine orcharding.

A method of improving on the present practice by employing an earthen pot instead of the injurious "box" has been patented and practically introduced by J. C. Schuler, of West Lake, La. The arrangement is represented in fig. 10, its main feature being an earthen pot which can be moved as the scar is lengthened, thus reducing the distance over which the resin has to flow, and with this the amount of volatilization and loss of spirits of turpentine. The method resembles that employed in France (see Report of Chief of Forestry, United States Department of Agriculture, 1892, page 347), and, though its general application in this country is not yet secured, it is certainly a step in the right direction.

Mr. Schuler admits that the first cost for providing the cups, putting them up, and removing them the second season raises the expense of working a crop of 10,000 cups for two seasons to $460, against $190 for cutting 10,000 boxes expended under the old system in working one crop for two seasons, all other expenses connected with the work being considered equal. On the other hand, Schuler claims that the difference is vastly overbalanced by the increased yield of crude turpentine obtained by his cup methods, amounting for one crop worked two years to 195 barrels, at $3.50 per barrel; after deducting the extra expense involved by his method, this would leave a net balance of $410 per crop in favor of the cup system. He also claims that this amount is still further augmented if the larger quantity of spirits of turpentine and the higher quality of resin obtained

from the dippings under his system are taken into account. On the first point he says that fully one-eighth of the crude turpentine brought to the still from the boxes consists of chips, sand, and other foreign matter, contaminations from which the product of the cups is entirely free. On the second point he refers to the high grades of rosin resulting from the distillation of the crude turpentine from the cups, which almost entirely classes with the highest and higher grades.

EFFECTS OF THE PRODUCTION OF NAVAL STORES UPON THE TIMBER, THE LIFE OF THE TREE, AND THE CONDITIONS OF THE FOREST.

In the present management of the turpentine orchards in the Southern pine forests a great deal of crude turpentine is wasted, much of the valuable spirits of turpentine is lost by volatilization in passing over the long chip face on its way to the box, and much of the resin is lowered in its grade and value by oxidation consequent to exposure and by admixture of foreign substances—bark, coal, dust, etc.

Concerning the effect of the tapping of the trees upon the timber, there exists no reason on physiologieal or anatomical grounds for considering it injurious, and the opinion held by many, that the qualities of timber are impaired by bleeding, finds no support when it is eonsidered that the heartwood remains unaffected. The resinous contents of the heartwood being solidified and the formation of the resin taking place only in the newly formed wood, the heartwood can not participate in the flow of the resin, the discharge being necessarily confined to the sapwood. This fact has been fully substantiated by the work of the Division of Forestry, by which it has not only been shown that the strength of the heartwood, the most important if not the only part of the tree used for lumber, has in no wise been diminished, but also that the durability of the timber, as far as it depends upon its resinous contents, can not be impaired by bleeding. It is only in that part of the butt log around the chip that the quality of the timber becomes somewhat impaired—the wood becoming highly charged with resin is rendered more brittle and harder to work, with a tendency to gum up the tools. Indirectly, however, a considerable proportion of the boxed timber becomes damaged if not utilized shortly after having been bled. It is often left standing for a number of years, exposed to various destructive agencies, such as insects and fire, followed by parasitic fungoid growth. Large capricorn beetles bore their way through the callus surrounding the chip and through and beyond the sapwood. Through the innumerable fissures which are caused by fires, air and water eharged with the spores of parasitic fungi find entrance to the body of the tree, causing disease and decay. The damage from these causes increases every year, so that from them alone the timber from a turpentine orchard abandoned for a dozen years was found damaged to the extent of fully 20 per cent. Although the loss of its resin by bleeding results physiologically in no direct injury to the tree, the wound inflicted by tapping, like any other wound, interferes with its healthy growth and, particularly in the case of trees of smaller size, causes their early decay. While the exuded resin covering the excoriated surface of the tree acts as an efficient antiseptic, affording a firm protection against the access of the spores of fungi, it endangers the life of the tree, if exposed to fire, by its greater inflammability, the heat produced by its flame being capable of killing the trees outright. Under the crude and inconsiderate manner of cutting the boxes, all of the trees of smaller size and many of the larger trees are blown down, and a considerable number of those remaining with their excoriated surfaces out of proportion to the recuperative power of the trees are doomed to perish sooner or later in consequence of such treatment.

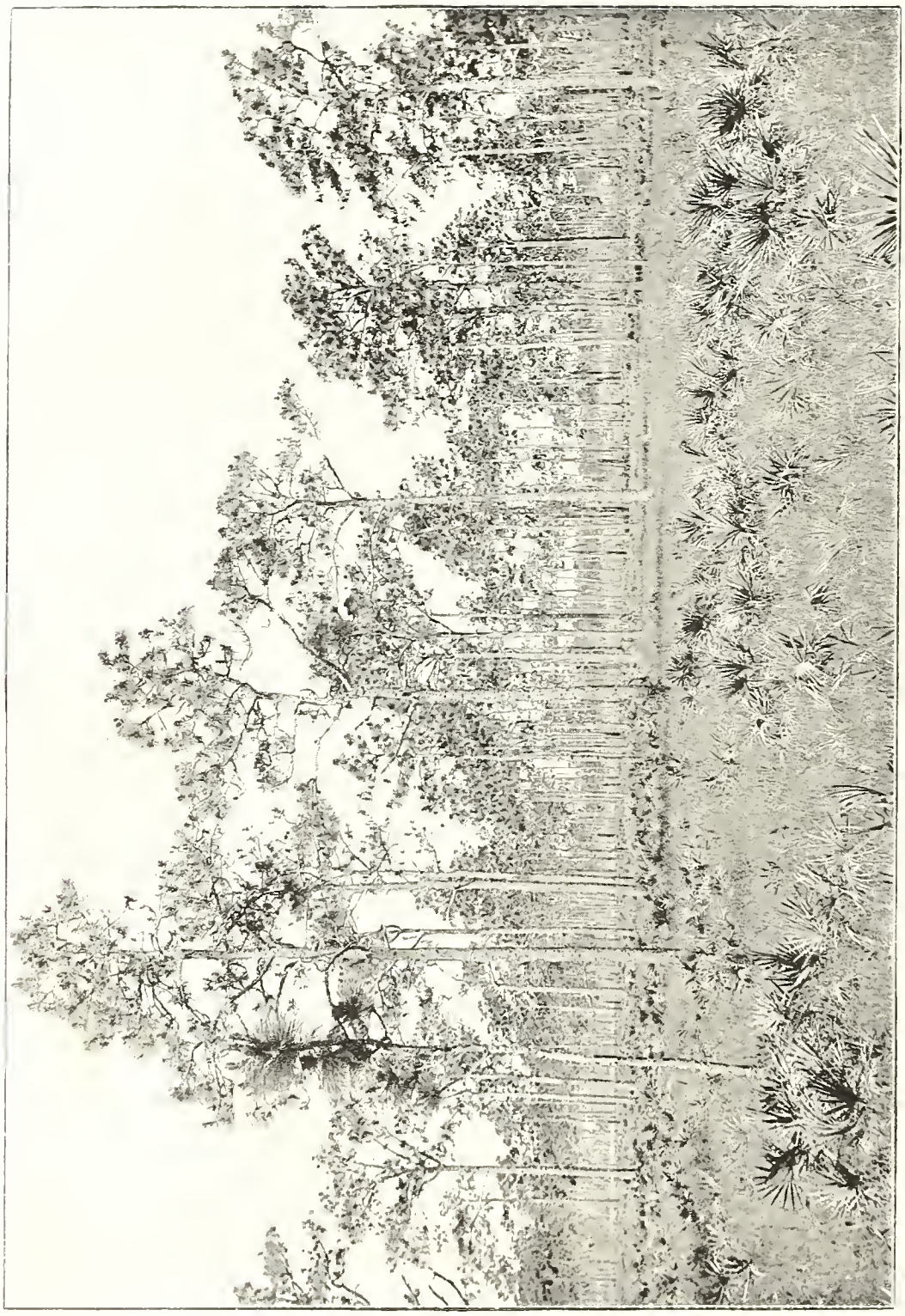
These injuries inflicted upon the individual trees, in connection with the fires started with the opening of the season one year after another, cause sueh damage to the forests as to effeet finally their total destruction. Fire being allowed to sweep over large areas, its foree increased in the turpentine orchards by the exposed resinous surfaces of the trees, and by trees blown down and the débris covering the ground, an immense amount of timber is destroyed. Trees which have not been killed outright by the fire, or have altogether escaped the danger, are doomed to speedy destruction by bark beetles and pine borers, which find a breeding place in the living trees prostrated by the winds during the summer, the broods of which rapidly infest the standing trees, whieh invariably succumb to the pest the same season. In consequenee, the forests invaded by turpentine orcharding present, in five or six years after they have been abandoned, a picture of ruin and desolation painful to behold, and in view of the destruction of the seedlings and the younger growth all hope of the restoration of these magnifieent forests is excluded.

ADDENDUM.

LONGLEAF PINE IN HIGHLANDS.

Under date of August 5, 1896, Dr. Mohr sends the following interesting note descriptive of a tract of Longleaf Pine grown at the remarkable altitude of 2,000 feet:

In my investigations of the flora of the region of greatest elevation in Alabama I was surprised to find the Longleaf Pine, which forms the greater part of the tree growth on the flanks of the mountains in the region of the State, to ascend to a height of 1 600 to 1,700 feet above the sea—(Chenawhaw Mountain, Clay County, 2,400 feet). According to the observation taken by Prof. E. S. Smith and Mr. Brewer, assistant geologist, at points of the same mountain range, 5 or 6 miles farther to the south, it appears that the Longleaf Pine is found at an elevation little short of 2,000 feet, whereas I found the tree to disappear at an elevation of about 1,500 feet on the same range (Blue Mountain or Talladega Mountain Range) about Chandler's Spring, Talladega County, and on the isolated ridges of the Alpine Mountains in the same county (in 1893). From my observations in former years I was convinced that the pine forests of the metamorphic regions of Alabama deserved no mention among the timber resources of the State, however valuable they might be as a resource for fuel in connection with the mineral resources of these parts of the State. I was not a little surprised to hear, on my trip of last week, of a sawmill with a daily output of from 65,000 to 70,000 feet of lumber of Longleaf Pine, situated in the lower part of Clay County at the outskirts of the geological formation mentioned. I visited, yesterday morning, the pine forests from which the supplies of this large and well conducted establishment, at Hollins on the Georgia Pacific Railroad, are drawn. There I found the foothills and narrow valleys between them, at an elevation of from 1,400 to 1,500 feet, covered with a truly magnificent forest of *Pinus palustris*, yielding to the acre as much merchantable timber as the best class of pinelands in the coast pine belt from Alabama to Texas. The trees are tall; some of them measured on the ground were found from 110 to 118 feet total height, with the crown 60 feet above the ground, and the shaft clear of heart and limb for almost the whole of that length; two cuts of 20 feet each above the stump are generally free from blemish. The surface soil appeared as arid and poor as that found on the steep declivities of the main ranges. Its pine timber growth was to me indeed an enigma, which, however, soon found its solution by examining in a deep cut the subsoil condition: the decomposed dioritic schist, forming a kind of soft marl for a great depth, offered no obstacle to the long taproot of the pine. These hills extend for a length of about 6 miles in a northeasterly direction by a width scarcely exceeding 2 miles. I could not learn that any other locality is found in the same geological formation of an equal extent with the same conditions of the timber growth.



CUBAN PINE FLATWOODS OF FLORIDA.

THE CUBAN PINE.

(PINUS HETEROPHYLLA (ELL.) Sudw.)

GEOGRAPHICAL DISTRIBUTION.
PRODUCTS.
CLASSIFICATION AND NOMENCLATURE.
DESCRIPTION AND MORPHOLOGICAL CHARACTERS.
PROGRESS OF DEVELOPMENT.
REQUIREMENTS FOR DEVELOPMENT.

THE CUBAN PINE.

(*Pinus heterophylla* (Ell.) Sudw.)

Synonyms: *Pinus taeda* var. *heterophylla* Elliott, Sk. ii. 636 (1824).
Pinus cubensis Grisebach in Mem. Am. Acad., viii. pt. 2, 530 (1863), not Hort. ex Gord. (1858).
Pinus cubensis var. *terthrocarpa* Wright in Grisebach. Cat. Pl. Cuben., 217 (1866).
Pinus elliottii Engelmann ex Vassey, Cat. Forest Trees, 30; in Rep. Com. Ag. 1875. 178 (1876).
Pinus elliottii Engelmann in Trans. St. Louis Acad., iv, 186, t. 1, 2, 3 (1879).
Pinus heterophylla (Ell.) Sudworth in Bull. Torr. Bot. Cl. XX, 45 (1893).

COMMON OR LOCAL NAMES.

Slash Pine (Ala., Miss., Ga., Fla.).
Swamp Pine (Fla., Miss., Ala.), in part.
Bastard Pine (Ala. lumbermen. Fla.).
Meadow Pine (Cal., Fla., E. Miss.), in part.
Pitch Pine (Fla.).
She Pitch Pine (Ga.).
She Pine (Ga. and Fla.).
Spruce Pine (So. Ala.).

THE CUBAN PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

Confined within narrow limits along the coast of the extreme Southern States east of the Mississippi River, little known and mostly confounded with its allied species, the value of the Cuban Pine has been scarcely recognized. A closer investigation of the properties of its wood, of its life history, and of the part it plays among the forest growth soon discloses its economic importance. Convinced that to meet proper appreciation the merits possessed by this pine need only to be made more generally known, their consideration in this place among the biological investigations of the more important timber trees of the coniferous order will explain itself.

This tree was not known to the earlier American botanists. Elliott first[1] took notice of it as a distinct form, and he regarded it as a variety of the Loblolly Pine. It remained still practically unknown as a separate species for another half century, until near the beginning of the past decade, when it was again brought to notice of botanists by Dr. Millishamp, of Bluffton, S. C.; Dr. Engelmann exhibited clearly its specific characters, and for the first time directed attention to the economic value of this pine by discussing the development of the tree and the qualities of its timber.[2] On account of the coarser grain of its wood and the large amount of sapwood, this timber was held to be of little value, and the tree received little or no attention by the lumberman. It is only very lately, especially since kiln-drying has become more general, that its value is being recognized and appreciated, and under the name of "Slash Pine" it is cut and sold without discrimination with the Longleaf Pine, with which it is usually associated.

GEOGRAPHICAL DISTRIBUTION.

The Cuban Pine is a tree of the coast region in the subtropical region of North America east of the Mississippi River, and also of the neighboring tropics, being found in Honduras and Cuba (see Pl. III). In the United States the tree is confined to the eastern belt of the Austro-riparian or Louisianian life zone of American biologists, from 33° north latitude in South Carolina along the coast to the extremity of the peninsula of Florida. Toward the west the tree extends along the coast of the Gulf to the Pearl River Valley. It is principally restricted to the coast plain, but on the Gulf Coast and along the water courses it extends inland to a distance of fully 60 miles from the sea. On the Atlantic Coast it penetrates the interior nearly to the limit of the coast pine belt, as has been observed in Georgia in the valley of the Ocmulgee River, over 100 miles distant from tide water. Groves of the Cuban pine skirt the low shores of the numerous inlets and estuaries of these coasts, and cover the outlying islands. More or less associated with the Loblolly and the Longleaf Pine, it forms a part of the timber growth of the open pine forests which in unbroken monotony cover the flats for long distances. It is only in the lower part of Florida, where the tree extends from the Atlantic across to the Gulf of Mexico, south of Cape Canaveral and Biscayne Bay, that, as the only pine there, the Cuban pine forms forests by itself. Toward the interior it occurs scattered among the varied growth of broad-leafed evergreens and cone-bearing trees which cover the swamps along the streams. Since it is invariably cut and sold

[1] Elliott, sketch 2, page 263.

[2] Engelmann: Revision of the genus *Pinus* and description of *Pinus elliottii*. Transactions St. Louis Acad. Sci., vol. 4, 1880.

without distinction, no figures can be given of its annual consumption, nor is it possible to form even an approximate estimate of the standing supplies. The old timber goes, of course, as fast as that of the Longleaf Pine, but in its reproduction it outstrips the latter. Wherever in the coast plain the original growth of the Longleaf Pine has been removed, the Cuban Pine takes, in a great measure, possession of the ground, in some localities associated with the Loblolly Pine. Young forests in every stage of growth are seen covering tracts of greater or lesser extent, promising important supplies of resinous products, timber, and fuel.

PRODUCTS.

As a timber tree the Cuban Pine is little inferior to the Longleaf Pine. It furnishes sticks of large dimensions free from blemish, rivaling in that respect that superior variety of the Loblolly Pine called Rosemary Pine, and there is no doubt that it was often confounded with this tree in the shipments of masts and long spars made in former years from the southern Atlantic and eastern Gulf ports. In the lumber mills on the Atlantic Coast the timber of this tree is indiscriminately sawn and shipped with that of the Longleaf Pine.

It remains yet to be proved whether the coarser structure of the wood of the Cuban Pine would render it less durable. It is certain, however, that this very cause, which might interfere with its resistance to atmospheric influences or to contact with the soil, will be found an advantage if the preservation of the timber is to be secured by its impregnation with antiseptic solutions, more open structure permitting readier infiltration.

Resinous products.—This pine abounds in resinous matter. The oleoresin, resin, or crude turpentine, when freshly exuded, is perfectly limpid, of honey-yellow color, less viscid than the resinous product of the Longleaf Pine, and to all appearances richer in volatile oil or spirits of turpentine, judging by the smaller amount of hard gum or scrape formed on the tree. A sample of the dip of the first year from South Carolina was to all appearance exposed for a short time in the box to atmospheric influences. Examined by Prof. E. Kremers, University of Wisconsin, the resin showed an emulsion-like appearance and separated upon standing into heavier granules and into a lighter, transparent, yellowish liquid. Its specific gravity at 20° C. was found 1.0253. D=32.423° (determined in 16.26 per cent alcoholic solution). Distilled with water, the sample yielded 16 per cent of oil of the specific gravity 0.865 (20° C.). D=9.620.

In view of the rapid destruction of the forests of Longleaf Pine, the principal source of resin, the future importance of the Cuban Pine in the production of naval stores becomes at once apparent, especially when it is considered that it reproduces itself so much more readily. Even now, on the coast of South Carolina and Georgia, a large proportion of resinous products is derived from the young growth of this pine, which, after the removal of the original timber growth, took possession of the ground. It is claimed by the turpentine gatherers in these States that at an age of from thirty to forty years the trees are sufficiently large for tapping with advantage, and that protected against fire a spontaneous renewal takes place, and after a period of forty years the new crop is ready for profitable exploitation.

In Washington County, Ala., on the more or less extensive flats that intervene between the low ridges covered with Longleaf Pine, the Cuban Pine furnishes considerable supplies of crude turpentine of superior quality. In this section the tree is known under the name of Spruce Pine, a misnomer, leading to its confusion with an entirely different tree, the true Southern Spruce Pine (*Pinus glabra*).

CLASSIFICATION AND NOMENCLATURE.

Pinus heterophylla is closely allied to the Longleaf Pine, forming with this and two other species inhabiting the nearest tropical regions—Cuba and Mexico—under the subgenus pinaster, a natural group of trees with heavy resinous wood, rigid long leaves from two to five in a sheath, and subterminal or lateral, horizontal or reflexed cones, designated by Englemann as the group of the Enaustrales, or longleaf pines. First distinguished by Elliott as *Pinus tæda* var. *heterophylla* and remaining subsequently unknown for more than fifty years, the specific characters of this pine were first recognized and fully described by Dr. Engelmann, who in honor of its discoverer distinguished the tree under the name of *Pinus elliottii*, finding himself soon afterwards convinced of the identity

of his species with *Pinus cubensis* of Grisebach. Recently these various forms were found to be the same as Elliott's, to which they have been referred with his varietal name *heterophylla* raised to specific rank. The tree is little known among the inhabitants of the region of its growth; it is generally regarded as a mere variety or bastard form of the Longleaf or the Loblolly Pine. In Florida, where best known, it is distinguished as the Slash Pine, or Swamp Pine; and in the flat woods along the seashore in Alabama and Mississippi as Meadow Pine. In a few localities in Alabama it is generally called Spruce Pine.

DESCRIPTION AND MORPHOLOGICAL CHARACTERS.

The leaves, two or three in a bundle, are surrounded by a smooth sheath from one-half to nearly an inch in length, which, close and smooth during the first season, become loose and shriveled in the second year (Pl. X, *d*). The leaves are from 8 to 12, mostly 9 inches in length and three-fourths of a line wide, glossy, of a deep-green color and closely serrulate with a short, rigid point, rounded on the back, the binary leaves deeply concave and the ternate bluntly keeled. They arise from the axils of fringed deciduous bracts, are densely crowded toward the end of the branches, and are shed by the close of the second season. Bundles with two leaves are most frequently observed in younger trees and almost invariably on the fertile branchlets.

The resin ducts are internal, variable in size, and in number from four to six and over, close to the thin-walled bundle sheaths, which inclose two closely approximate fibrovascular bundles, often coalescing. The fibrovascular region, like the ducts, shows no hypodermal or strengthening cells. The hypodermal cells underlying the epidermis are as large as the epidermal cells, in the angles of one or several layers.

Flowers.—The catkin-like male flowers (Pl. X, *a*, *b*), from 1½ to 2 inches long, are of dark purple (royal purple) color, supported on a short stalk and surrounded by about a dozen involucral coriaceous bracts, of which the lowest pair is strongly keeled (Pl. X, *b*, slightly magnified), the others being oblong with fringed edges. From ten to twenty of these cylindrical flowers are crowded in dense clusters below the apex of the youngest shoots, and are shed almost immediately after the discharge of their abundant pollen. The anthers are crowned with a purplish crescent-shaped denticulate crest. The female flowers form an oval, pink-colored ament borne on a stalk, from one-half to 1 inch in length, which singly, more frequently several in number, are produced close to the terminal bud of the shoot of the season (Pl. X, *d*). First erect, they are, at the lapse of a month, horizontally reflected, the shoot bearing them increasing rapidly in length during the same time, long before the unfolding of its leaf buds. The involucral scales or bracts which surround the female catkin are more numerous, narrower, longer, and more membranaceous than those forming the involucra of the male flowers. The carpellary scales are round with a slender, erect tip, their lower half covered by the broad retuse bract.

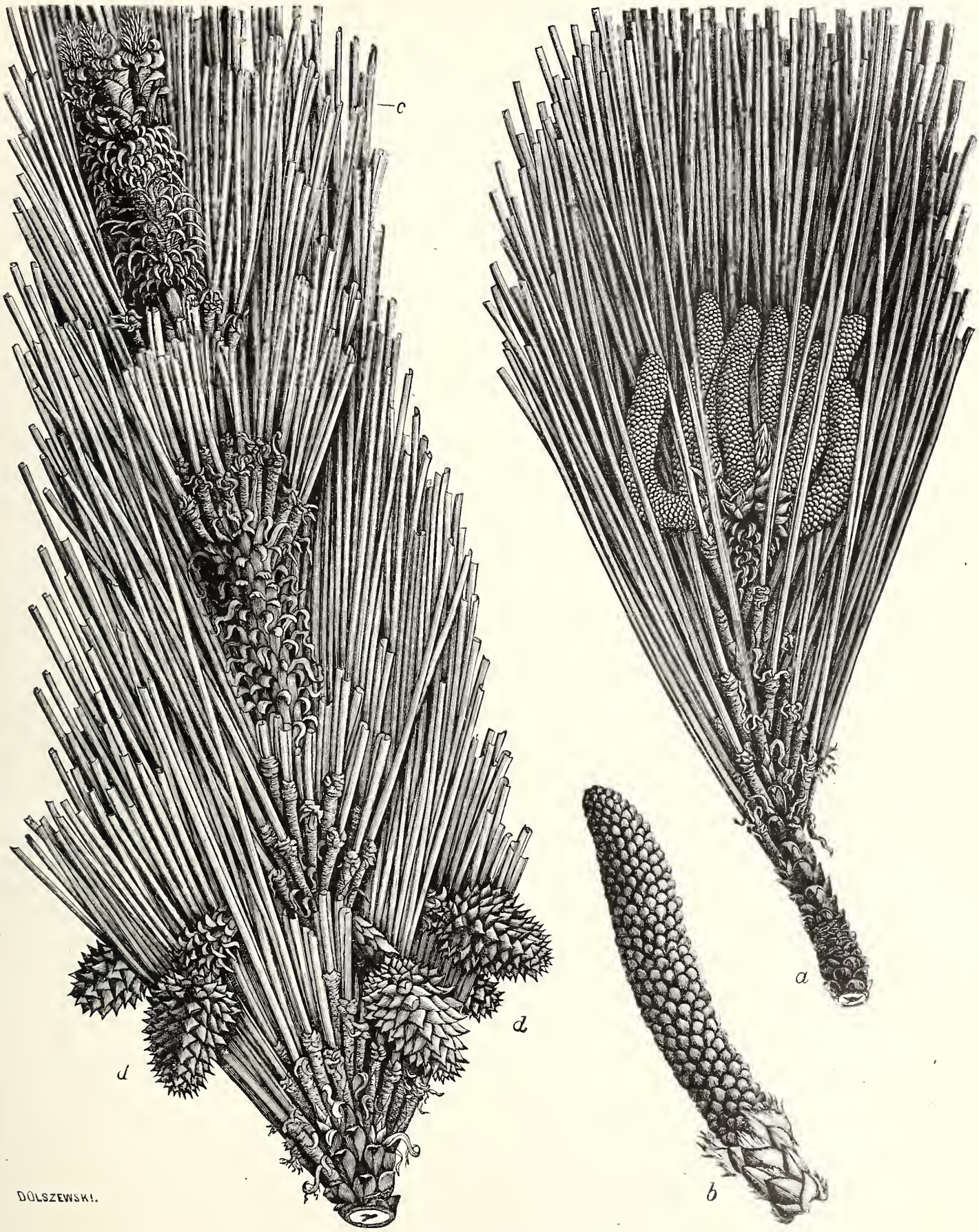
A tree discovered by Dr. Mellichamps near Bluffton, S. C., showed the remarkable anomaly of producing androgynous flowers regularly every season. In most of the specimens examined every one of the male flowers clustering around the base of the terminal bud of the very young shoot had the upper part of the floral axis covered with female flowers, appearing like a distinct inflorescence superimposed upon the staminodial column, occupying generally one-third of its height. In one of the flowers they were seen to extend near to its base. In a single instance it was observed that the female flowers extended on one side of the staminodial column in a narrow streak among the stamens.

In a specimen from the same locality the terminal shoot of the season, exceeding in length the male flowers by which its base was surrounded, was bearing a normal subterminal female ament. The short-stalked cones are ovate or conical, rather obtuse, horizontally reflexed, from 4 to 5 inches long, about 2½ inches greatest width, of glossy leather-brown or hazel color (Pl. XI, *a* and *b*); scales about 2 inches long averaging five-eighths of an inch in width, somewhat flexible, the prominent ridge of the pyramidal striated umbo with a short, mostly straight, strong prickle (Pl. XI, *c* and *d*). By the end of the first season the conelets are scarcely an inch long (Pl. X, *d*). Before the close of the summer of the succeeding year, the cones have reached their full size, maturing during the month of October. In the ripe cones, already described, the apophyses of the scales in the lower rows are almost pointless, becoming on the upper strongly mucronate. The cones remain on the tree until the approach of the next summer, leaving on their separation the lowest rows of the scales behind.

EXPLANATION OF PLATE X.

Figures natural size, except where otherwise noted.

Fig. *a*, branch with young shoot of the season bearing a cluster of male flowers; *b*, male flower detached showing basal involucral bracts, magnified three diameters; *c*, branch bearing three subterminal female flowers; *d*, *d*, characteristically reflexed immature cones of one season's growth.



DOLSZEWSKI.

PINUS HETEROPHYLLA: MALE AND FEMALE FLOWERS.

The triangular black roughish seeds 2½ to a little over 3 lines long, with a few faint ridges; the brown, obtuse, and somewhat oblique wing (Pl. XI, *e*, *f*, *g*) about 1 inch in length is deciduous in germination. This species at all stages of growth can be distinguished from the Loblolly Pine by the deep-green foliage, the glaucous hue of the young, tender shoots, and varying number of leaves in a bundle—from the Longleaf Pine by the thinner, almost smooth, terminal buds, and in the adult state, from both of these species, with which it is found frequently associated, by its cones.

THE WOOD.

As in the Loblolly, the sapwood is wide in the young trees, measuring usually about 4 inches and forming in thrifty trees fifty to seventy years old about 80 per cent of the total volume. As the trees grow older, however, this preponderance of sapwood ceases, and in trees one hundred and fifty to two hundred years old only 35 to 50 per cent of the total volume of the trunk was found to be composed of sapwood. As in the case of the pines already mentioned, the change from sapwood to heartwood begins when the tree (or disk) is about twenty-five to thirty years old, and the process is retarded as the tree (or disk) grows older, so that when any one disk is sixty years old the sapwood contains about forty rings, and reaches eighty rings or more by the time the tree (or disk) is two hundred years of age. As a consequence the sapwood of the disks of the main part of the trunk in old trees is formed of nearly the same number of rings, and only near the top a marked diminution appears, while in a tree sixty years old the sapwood of the stump may have forty rings and that of a disk 40 feet from the ground only twenty-five rings. As in other pines, the width of the sapwood is quite variable and is always greatest in young and thrifty trees.

When green the wood of this species is too heavy to float well; its weight varies chiefly with the amount of sapwood, and is therefore greatest in sapling timber. The sapwood itself is frequently heavier than water, and where the water in the sapwood and a large amount of resin in the heartwood combine, the weight of the entire disk frequently approaches 60 pounds to the cubic foot.

Kiln-dried, the wood of trees one hundred to one hundred and fifty years old was found on an average to weigh about 39 pounds per cubic foot, thus excelling in weight even the valuable Longleaf Pine. The wood of very young trees is decidedly lighter, as is also that of very old trees, the heaviest wood being formed during the age of thriftiest growth or between the twentieth and eightieth year. The presence of resin in the heartwood, as conspicuous in this species as in Longleaf Pine, materially adds to the weight of the wood, so that the heartwood of old trees is invariably heavier than the same wood had been while in a sapwood condition. As in other pines, the butt is heaviest and the toplog lightest; thus in trees over one hundred and fifty years of age the wood at the butt weighs 44 pounds per cubic foot, 37 pounds at 38 feet, and only 32 pounds at 60 feet from the stump, a difference amounting to over 25 per cent. This difference is greatest in the young sapling and is remarkably uniform for all adult trees examined.

In strength, as in weight, the wood of Cuban Pine excels. The following figures represent the general average of a long series of experiments on wood especially collected:

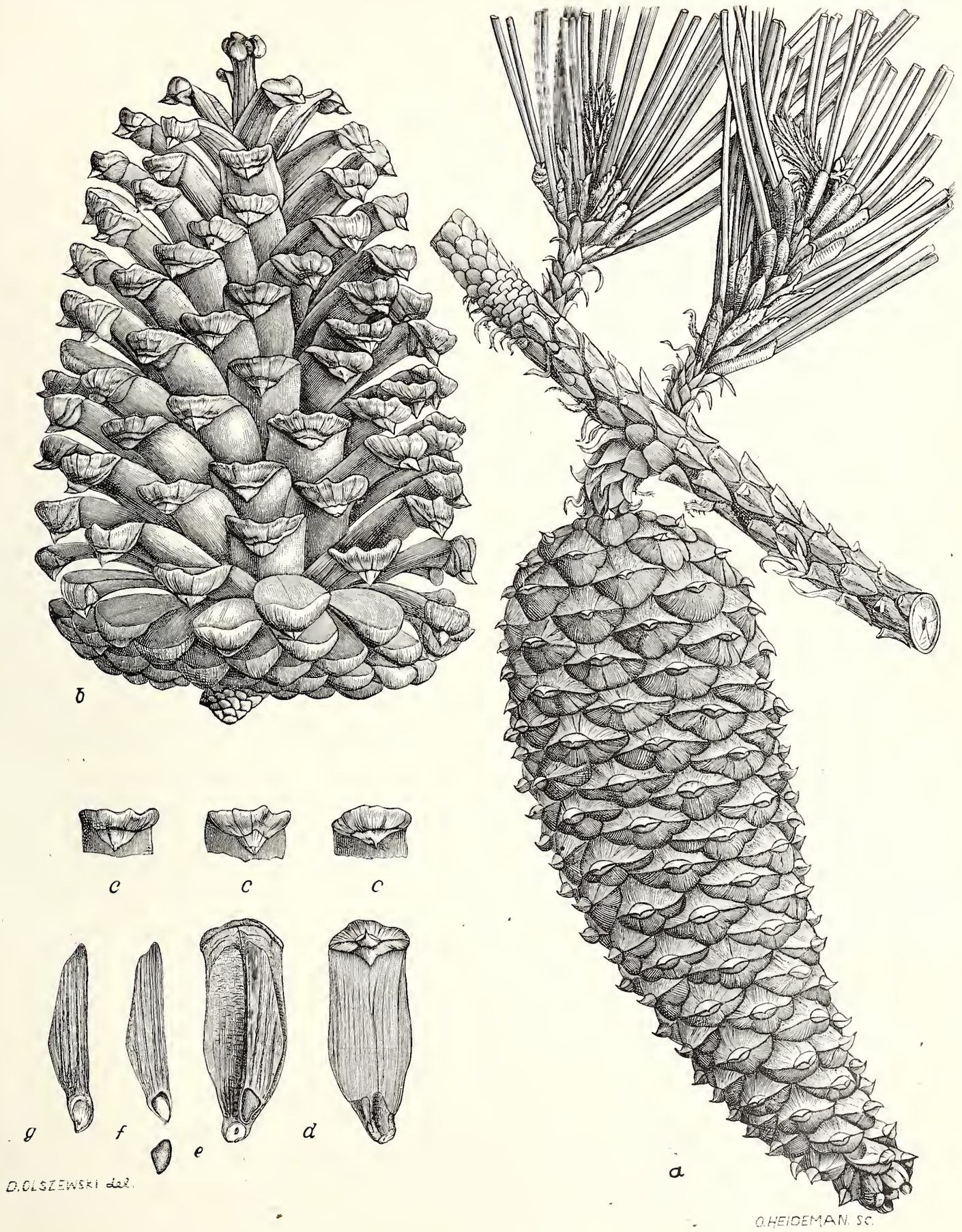
	Lbs. per sq. inch.
Modulus of elasticity	2,300,000
Transverse strength	11,900
Compression endwise	7,850
Shearing	680
Tension	14,300

The average weight of the pieces tested was 49 pounds per cubic foot, the outer lighter part of the old trees having largely been cut away in shaping the pieces, so that only heavy wood had been tested. The above figures require, therefore, a reduction of about 20 per cent to represent the true average strength of all the wood of entire trees.

The amount of water contained in the fresh wood depends on the proportion of sapwood. In this latter it forms about 60 per cent of the weight of fresh wood; in the heartwood only about 20 per cent. Accordingly, fresh logs of sapling timber seventy years old have about 45 per cent, logs of trees over one hundred and fifty years old only about 30 per cent of water. The wood dries easily and without great injury, even if seasoned in the dry kiln.

EXPLANATION OF PLATE XI

Fig. *a*, section of a branch bearing a mature closed cone (October); *b*, mature open cone after shedding seed; *c*, *c*, *c*, tips of cone scales showing variation in form of apophysis and stout prickle; *d*, cone scale, outer or dorsal side; *e*, inner or ventral side of cone scale with seed in place; *f*, seed with wing detached; *g*, seed and wing intact.



PINUS HETEROPHYLLA: CONE AND SEED.

The shrinkage during drying is very considerable for sapwood, and therefore all young timber, but is not as great for old timber as might be expected on account of the great weight of the wood. Young timber shrinks from 12 to 13 per cent of its volume, the wood of old trees (over one hundred and fifty years) only about 11 per cent, and in all trees the amount of shrinkage is greatest in the heaviest disk of the butt and decreases upward very much in proportion of the decrease in weight.

In its structure the wood resembles that of the Loblolly in every respect. Summerwood and springwood are sharply defined, giving rise to alternating bands of light-colored, soft and dark-colored hard bands of wood conspicuous in every section. For details of structure see the comparative study by Mr. Roth appended to these monographs.

PROGRESS OF DEVELOPMENT.

This is the earliest flowering of the Southern pines. The buds of the male flowers make their appearance in the early part of December, and the flowers open during the last days of January and during the first week of February. This species produces abundant crops of cones every year, almost without failure; they ripen in the fall of the second year; the seeds are discharged through the winter of the second year until spring. Germinating easily, their seedlings are found to come up copiously from early in the spring to the beginning of the summer in old fields and on every opening in the vicinity of the parent trees, wherever the rays of the sun reach the ground. The plantlets bear six to seven seed-leaves (cotyledons). As soon as these have fairly expanded the terminal bud develops rapidly, and the first internode of the stem, increasing quickly in length, is densely covered with the soft, narrow, linear, pointed, primary leaves, which are fully an inch long. Before the end of the second month, in the axils of some of the leaves, the undeveloped branchlets, bearing the fascicle of the foliage leaves, make their appearance. With the further development of the foliage leaves, increasing in number during the growing season, the primary leaves wither away. By the close of the first season the plantlets are from 8 to 9 inches high, with a very slender taproot and many lateral rootlets near its upper end. After the beginning of the second season but few of the primary leaves are found to support the buds of the foliage leaves. The tendency to the production of secondary axes becomes manifest by the appearance of a single branchlet; on having reached the end of their second year the plants are from 12 to 15 inches high, with a taproot not more than 4 inches long; at the end of their third year they average little less than 2 feet in height, with the taproot 6 inches long—the laterals being much longer. The crown from this period develops in regular whorls for a long succession of years.

The Cuban Pine, in its rate of growth and when fully grown, exceeds in its dimensions the Longleaf Pine. The taproot, less powerful than in its allies, is assisted by mighty lateral roots running near the surface of the ground to support the tall, sturdy trunk, rising to a height of 110 or 115 feet, with a diameter of 2½, not unfrequently exceeding 3, feet, clear of limbs for a height of from 60 to 70 feet above the ground. The heavy limbs are horizontally spreading, from 22 to 24 feet at their greatest length, somewhat irregularly disposed; they form in the trees of full growth a rather dense crown of rounded outline. Trees of the dimensions mentioned, having passed the fullness of their growth, are found to be from one hundred to one hundred and forty years old, according to the surrounding conditions. The thick bark is of a clear, reddish color, laminated, and exfoliating in thin, broad, purplish flakes.

Seedlings of the Longleaf Pine, which those of the Cuban Pine somewhat resemble, can be readily distinguished at this period by the disproportion of height and diameter and absence of branch growth in the former. The rate of growth differs, of course, according to the conditions of soil and exposure.

Saplings showing five rings of annual growth were found from 4½ to nearly 6 feet in height, with a diameter of from three-fourths to seven-eighths of an inch; between the age of from ten to twelve years the trees measure from 10 to 18 feet in height, with the stem clear for over half its length—even when grown in the open—and from 2 up to 4 inches in diameter. From this stage on the rate of growth proceeds most rapidly. At eighteen and twenty years heights of 40 to 50 feet and over, and diameters from 9 to 10 inches across the stump, cut close to the ground, are attained.

The trees of the extensive groves of Cuban Pine in the vicinity of Mobile upon the loamy lands of the coast plain, which have sprung up since 1864, when these lands were completely stripped of all arboreal growth, average at present between 50 and 60 feet in height by a diameter of from 14 to 16 inches breast high. Trees of second growth, forming open groves on lands of similar character, and also more or less deficient in drainage, forty-five to sixty-five years old, measure from 65 to 85 feet in height and from 15 to 20 inches in diameter breast high.

At the edge of a heavily wooded swamp, in a perpetually wet, sandy, and mucky soil and skirted by large Longleaf Pines occupying the steep slope rising from the bottom, a tree measuring 114 feet in height, with a diameter of 24 inches breast high, the trunk clear of limbs for a length of fully 60 feet, showed one hundred and thirty-five rings of annual growth. Another tree felled deeper in the same swamp, of lank growth, with a poorly developed crown, rising to a height of 88 feet and towering above the dense growth of black gums, swamp maples, and white bays, was found to measure only 15½ inches in diameter, with almost the same number of annual rings. Trees of second growth which have sprung up in clearings with a drier surface soil underlaid by a clayey substratum, with free exposure to sunlight and air, reach in little over half the time the full size of those produced in the forest-covered swamps.

TABLE 1.—*Growth of Cuban Pine during first stages of life, from four to twenty years.*

No. of tree.	Rings in stump.	Diameter.		Height.			Locality.	Remarks.
		Breast high.	Across stump.	Total.	To first limb.	Crown.		
		Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
1	4	½	.....	3½	.....	.....	.....	
2	5	1½	.....	4½	.....	.....	.....	Nos. 1 to 5, near Whistler, Ala.
3	5	1¼	.....	6¼	.....	.....	.....	Wet, sandy, flat soil very poor; open thickets in the clearing of the forest.
4	6	1½	.....	8¼	.....	.....	.....	
5	8	1⅝	.....	8⅓	.....	.....	.....	
236	9	2	2¼	17	10	7	Whistler, Ala	Exposure partially free; suppressed soil; slushy.
296	9	2	2⅛	19	10	9	Ridgeland, S. C	Old field; soil fresh; from midst of dense grove.
295	9	.....	.....	18	8	10	do	
235	10	2	.....	18	7	11	Whistler, Ala	Open edge of swamp, somewhat suppressed.
223	11	3¾	4	26	13	13	do	Partially free; edge of swamp.
294	11	4	4½	28	14	14	Ridgeland, S. C	Open grove of saplings; soil fresh; old field.
6	12	3¾	.....	19	.....	.....	Mobile, Ala	Grove of young trees; crown covered partially by large pines; soil conditions, best.
291	13	6	.....	29	13	16	Ridgeland, S. C	
292	14	4	4½	27	.....	.....	do	Old field.
7	15	8½	.....	37	.....	.....	Mobile, Ala	Midst of dense thicket; in the shade; suppressed: soil conditions, best.
8	15	9	.....	31	.....	.....	do	Do.
262	16	6	7	36	18	26	Ridgeland, S. C	Exposure free; old field; soil black, mucky.
9	16	8	.....	46	27	19	Mobile, Ala	In the shade of large pines.
10	17	8¼	.....	46	.....	.....	do	Do.
232	17	6½	6½	38	15	13	Ridgeland, S. C	Swamp soil; slushy; suppressed.
231	18	6	6½	50	20	.....	do	Exposure free; soil fresh, good.
11	18	8	.....	47	.....	.....	Mobile, Ala	Under cover of large pines; soil conditions, good.
12	18	9	.....	37	14	23	do	Do.
13	21	10½	.....	53	27	26	do	Free exposure.

TABLE II.—*Growth of Cuban Pine during middle and last stages of life, from forty to one hundred and forty-five years.*

No. of tree.	Rings in stump.	Diameter.				Height.			Locality.	Remarks.
		Breast high.	Across stump.	Below crown.	Mean.	Total height.	Length to crown, clear.	Length of crown.		
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
1	40	14½				60	39	24	Mobile, Ala	Midst of grove, crowded; damp, sandy loam; clay subsoil; surface flat.
290	43	12				66	34	32	Ridgeland, S. C	Exposure free; edge of swamp; soil perpetually damp.
230	51	12½				87	51		Whistler, Ala	Edge swamp; soil fresh to damp; growth lank; sap, 5 inches.
2	52	17	17½			83	50	36	Mobile, Ala	Edge of grove.
3	55	19				74	40		Stockton, Baldwin County, Ala.	Exposure free; springy hillside; soil coarse, sandy, and gravelly.
4	55	20	25	13½		82	50	32	Mobile, Ala	Exposure free; open grove.
5	56	20	24	19		79	47	32	do	Do.
289	60	16				90	59	31	Ridgeland, S.C	Low pine flat, open; soil moist and black, sour.
288	70	21				83	41	42	do	Exposure free; soil moist and black, sour.
6	87	20				85				Springhill edge of swamp; damp, sandy.
286	101	24				98	48	50	Ridgeland, S.C	Exposure free; near border of swamp; pine flat, badly drained.
7	110	22				90	60	30		Springhill rich hummock, perpetually damp; magnolia, red bay, spruce gum; Census 1880.
227	110	20				113	71	42	Whistler, Ala	Exposure free; edge of swamp; soil fresh; stick perfectly clear for 52 feet; sap, 2½ inches.
225	126	26				130	78	52	do	Timber perfect for 60 feet.
8	133	24	25	14½	21½	118	60	58	do	Exposure free; somewhat suppressed by longleaf pine; edge of swamp.
226	127	20				104	80	24	do	Exposure free; lank, tall; red heart above 54 feet.
228	132	22				119	73		do	Base of hill; a fine-looking tree; timber clear for 50 feet.
229	145	26				116	73		do	Swamp always slushy; free from knots for over 65 feet.
9	145	12½		7½		67	21		do	Of suppressed growth; in middle of swamp; soil pure sand, mostly covered with water.

From Table III the rapid growth of this species is quite apparent. It will be observed that good trees are about 20 feet high at ten, 45 feet at twenty, and over 80 feet high at fifty years of age, when the rapid rate of upward growth comes to a stop. It appears, also, that the greatest mass of wood for any decade is found at the early age of fifty, the growth in volume being nearly 15 cubic feet for these ten years, and that at ninety the growth in volume is only about two-thirds of the maximum; that at one hundred years the average annual growth nearly equals the current growth, thus indicating that the age of proper exploitation has been reached, i. e., that now the tree is ripe for the ax, as far as profitable growth, represented in volume accretion, is concerned.

TABLE III.—*Growth of Cuban Pine.*

Age.	Diameter with bark (breast high).	Length of log with upper diameter of 5 inches.	Height of tree.	Volume.		Periodical growth for each decade.					Average annual accretion.	Current accretion.
				Tree.	Log up to 5 inches diameter.	Decade.	Diameter.	Height.	Area of cross section.	Volume.		
	Inches.	*Feet.*	*Feet.*	*Cubic feet.*	*Cubic feet.*		*Inches.*	*Feet.*	*Sq. feet.*	*Cubic feet.*	*Cub. feet.*	*Cub. feet.*
10	2.9		20	0.50		First	2.1	20	0.02	0.50	0.05	0.05
20	5.9	5	45	4.24	2.44	Second	2.6	25	.10	3.74	.21	.37
30	9.3	24	66	14.95	13.06	Third	3.0	21	.20	10.71	.50	1.07
40	12.3	40	75	29.70	29.23	Fourth	2.6	9	.26	14.75	.74	1.47
50	14.8	50	83	47.01	45.53	Fifth	2.5	8	.31	17.31	.94	1.73
60	16.0	60	89	59.65	58.35	Sixth	1.2	6	.18	12.64	.99	1.26
70	17.6	69	93	72.25	71.17	Seventh	1.2	4	.19	12.60	1.03	1.26
80	18.8	76	96	84.05	83.15	Eighth	1.2	3	.21	11.80	1.05	1.18
90	20.0	83	99	95.03	94.31	Ninth	1.2	3	.22	10.98	1.05	1.10
100	21.4	90	101	105.97	105.48	Tenth	1.0	2	.20	10.94	1.06	1.09
110	22.4	96	103	115.58	115.27	Eleventh	1.0	2	.20	9.61	1.05	.96
120	23.4	100	105	125.18	124.96	Twelfth	1.0	2	.25	9.60	1.04	.96

REQUIREMENTS FOR DEVELOPMENT.

Soil.—For its best development the Cuban Pine requires a light, sandy, but constantly damp soil, which is attained where the sandy surface is underlaid by a loamy subsoil retentive of moisture but sufficiently loose to give the roots unhindered access. Such conditions are found on the lands rising above the perpetually wet swamps. On the flats, with a soil of fine, compact sand, devoid of all drainage and underlaid by a hardpan, where nothing but the Saw Palmetto appears to thrive, the tree remains of low, stunted growth, scarcely ever reaching medium size. In the depth of the swamp, with the soil wet and slushy throughout the year, where the tree is commonly met with, closely surrounded by White Bay, Red Bay, Black Gum, Titi, and White Cedar towering high above it, it is of slow growth and frequently affected by red heart or red rot, particularly near its northern limit. It is never found in alluvial bottoms, and eschews the dry, pine-barren hills, requiring a moderate but sure and even supply of soil moisture.

Climate.—The range of its distribution coincides with the area of greatest rainfall in the Southern States, which, evenly distributed through all seasons, amounts for the year, in the mean, to 60 and 64 inches.

The Cuban Pine demands a warm climate, free from excesses in the range of temperature, as is afforded by the vicinity of the sea. It is found in greatest abundance and most perfect within the isothermal lines of 64° and 68° F., with a minimum of but a few degrees below the freezing point. The tree, as observed at Mobile, has escaped uninjured the severe and unprecedented long spell of ice and snow during the latter part of January and first week of February, 1895, when the thermometer fell as low as 11° F., the flowers unfolding unimpaired by frost during the succeeding first days of milder weather.

In its dependence on light it is less exacting than either the Longleaf Pine or the Loblolly Pine. It appears to thrive, from the earliest stage of its development, as well when partially shaded as in the open, in this respect resembling the Southern Spruce Pine. It is due to these facts, combined with the rapid progress of its growth from the earliest stage, that the Cuban Pine is gaining the upper hand over the offspring of the light-requiring Longleaf Pine, which, on the damp soil of the coast plain, is soon outstripped and finally almost completely suppressed by the seedlings of this tree.

In the inherent capacity for natural reproduction, or in the advantages for the renewal of its forests by man, the Cuban Pine is not surpassed by any other of the species with which it is found associated. This tree commends itself strongly to the tree planter in the coast plain of the lower South. Producing seeds in abundance regularly and with certainty, being less exacting in its demands for direct sunlight, and hence successfully resisting the encroachment of competing species, being less liable to succumb to the destructive agencies of fire on account of its more rapid development in early life, it has greater promise of success than the others. If to this is added the rapid rate of growth, the great value of its timber, being equal to the Longleaf, if not superior, and the abundant yield of its valuable resinous product, it becomes evident that in the reforestation of the low pine lands of the Southern coast region the Cuban pine is to be preferred to any other, not only within its original boundaries, but as far beyond its range of natural distribution as the climatic requirements of the tree will permit.

SHORTLEAF PINE (PINUS ECHINATA), FOREST-GROWN SPECIMENS IN MISSOURI.

THE SHORTLEAF PINE.

(PINUS ECHINATA Miller.)

ECONOMIC HISTORY AND DISTRIBUTION.
BOTANICAL DESCRIPTION.
DESCRIPTION OF WOOD.
PROGRESS OF DEVELOPMENT.
CONDITIONS OF DEVELOPMENT.
FOREST MANAGEMENT.

THE SHORTLEAF PINE.

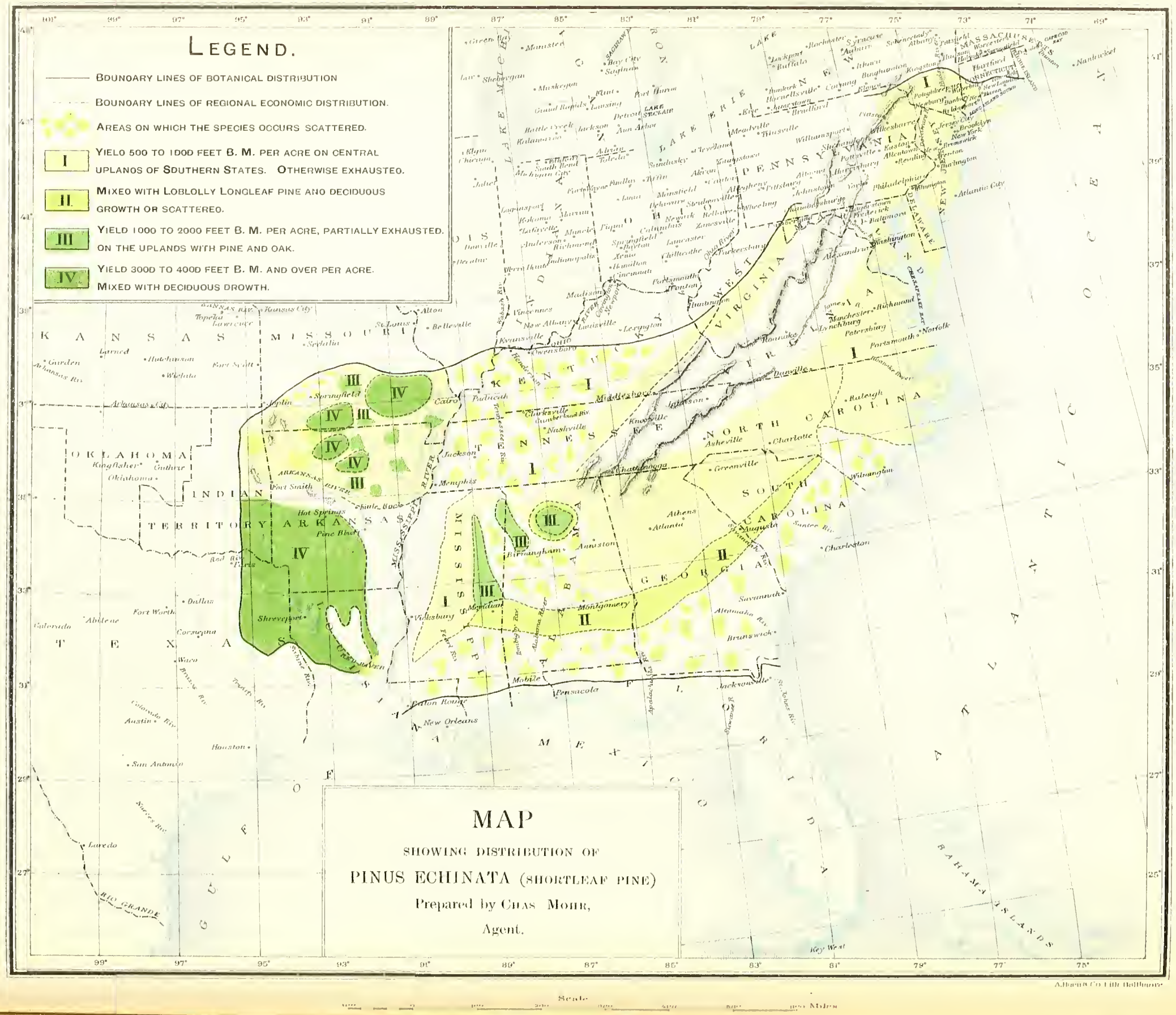
(*Pinus echinata* Miller.)

Synonyms: *Pinus echinata* Miller, Gard. Diet., ed. 8, No. 12 (1768).
Pinus virginiana var. *echinata* Du Roi, Harbk., ii, 38 (1772).
Pinus tæda γ variabilis Aiton, Hort. Kew., ed. 1, iii, 368 (1789).
Pinus mitis Michaux, Fl. Bor. Am., ii, 204 (1803).
Pinus variabilis Lambert, Pinus, ed. 1, i, 22, t. 15 (1803).
Pinus roxleana Jamieson ex Lindley, in Journ. Hort. Soc., ix, 52 (1855).
Pinus intermedia Fischer ex Gordon, Pinetum, ed. 1, 170 (1858), not Du Roi (1772).
Pinus rigida Porcher, Resources S. States, 504 (1863), not Miller (1768).
Pinus lutea Loddiges ex Gordon, Pinetum, ed. 1, 170 (1858), not Walter (1788).
Pinus roylei Lindley ex Gord., l. c.

COMMON OR LOCAL NAMES.

Yellow Pine (N. Y., N. J., Pa., Del., Va., N. C., Ala., Miss., La., Ark., Mo., Ill., Ind., Kans. (scaree), Ohio).
Shortleaved Pine (N. C., S. C., Ga., Ala., Miss., Fla., La., Tex., Ark.).
Spruce Pine (Del., Miss., Ark.).
Bull Pine (Va.).
Short Schat Pine (Del.).
Pitch Pine (Mo.).
Poor Pine (Fla.).
Shortleaved Yellow Pine.
Yellow Pine (N. C., Va.; Eng. lit.)
Virginia Yellow Pine (Va.) in part.
North Carolina Yellow Pine (N. C., Va.) in part.
North Carolina Pine (N. C., Va.) in part.
Carolina Pine (N. C., Va.) in part.
Slash Pine (N. C., Va.) in part.
Oldfield Pine (Ala., Miss.).

SHORTLEAF PINE (PINUS ECHINATA), A ROADSIDE SPECIMEN IN NORTH CAROLINA.


LEGEND.
BOUNDARY LINES OF BOTANICAL DISTRIBUTION
BOUNDARY LINES OF REGIONAL ECONOMIC DISTRIBUTION.
AREAS ON WHICH THE SPECIES OCCURS SCATTERED.
I YIELD 500 TO 1000 FEET B. M. PER ACRE ON CENTRAL UPLANDS OF SOUTHERN STATES. OTHERWISE EXHAUSTED.
II MIXED WITH LOBLOLLY LONGLEAF PINE AND DECIDUOUS GROWTH OR SCATTERED.
III YIELD 1000 TO 2000 FEET B. M. PER ACRE, PARTIALLY EXHAUSTED. ON THE UPLANDS WITH PINE AND OAK.
IV YIELD 3000 TO 4000 FEET B. M. AND OVER PER ACRE. MIXED WITH DECIDUOUS GROWTH.
MAP
SHOWING DISTRIBUTION OF
PINUS ECHINATA (SHORTLEAF PINE)
Prepared by CHAS MOHR,
Agent.
KANSAS
MISSOURI
OKLAHOMA
INDIAN TERRITORY
ARKANSAS
TEXAS
LOUISIANA
MISSISSIPPI
ALABAMA
GEORGIA
SOUTH CAROLINA
NORTH CAROLINA
TENNESSEE
KENTUCKY
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MASSACHUSETTS
CONNECTICUT
DELAWARE
FLORIDA
GULF OF MEXICO
ATLANTIC OCEAN
BAHAMA ISLANDS
RIO GRANDE
Scale
Miles

THE SHORTLEAF PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

Among the timber trees of the Atlantic forest region the Shortleaf Pine ranks with the first of those noted for their economic importance. Equally abundant, distributed over a wider area, and in the quality of its wood but little inferior, it takes its place next to the Longleaf Pine. When maintenance of forest and production of timber under a rational system of forestry is to become the rule, this species above all others of southerly distribution will claim attention, for it can be safely asserted that of the coniferous trees adapted to the climatic conditions of the Southern Atlantic forest, no other can be found of better promise for the production of valuable timber in the shortest time.

HISTORICAL.

The Shortleaf Pine, besides furnishing to the colonists the supplies of pine timber required for the construction of their dwellings, formed in early colonial times an article of export to the mother country and the West Indies. Michaux, the younger, writing in the first years of this century, speaks of this timber tree as becoming scarce near the ports. It seems that the specific characters of this tree were but imperfectly understood by the earlier investigators of our sylva. They were first accurately defined by Michaux, the father, who described this tree in his Flora Americana Borealis II, 204 (1803), under the name of *Pinus mitis*. A still more detailed description was soon afterwards given by Michaux, the son, in his work on American forest trees (Hist. Arb. Amer., 1, 52, t. 3, 1810), with a full account of its value as a timber tree, the qualities and uses of its wood, and all that was known in those days of its place in the forest. Besides the account given of the tree by the Rev. M. A. Curtis, of North Carolina, in his "Trees of North Carolina," little has been added to our knowledge of this pine until the publication in Professor Sargent's report on the Forests of North America,[1] of the results of the investigation which the writer had carried on in the Gulf States,[2] and Professor Harvey in Arkansas.[3]

For valuable information on the occurrence of this pine on the Atlantic Coast and west of the Alleghany Mountains, the writer is indebted to the kindness of correspondents active in the field of botany. In regard to the area over which this species is found distributed in the Southern States, the information contained in the physiographic descriptions of the several counties of the cotton States, in Professor Hilgard's report on cotton production,[4] were chiefly relied upon.

GEOGRAPHICAL DISTRIBUTION.

The Shortleaf Pine is widely distributed from the Atlantic Seaboard to the treeless plains of the Indian Territory under 95° west longitude over 23½° from east to west and 10° from south to north, namely, from 31° north latitude to Long Island, New York, or 41° north latitude along the Atlantic Coast, while in the interior it only reaches to 39° in western Virginia. According to F. A. Michaux, the Shortleaf Pine extended originally as far north as Albany, N. Y. The tree is at present not known in New York outside of Long Island, and its existence even in Pennsylvania is considered

[1] Forest of North America, Volume IX of Tenth Census. (C. S. Sargent, 1880.)
[2] C. Mohr: "Forest Trees of the Gulf Region" (Am. Jour. Forestry, Vol. I, 1883).
[3] "Forest Trees of Arkansas." (Harvey: Am. Jour. of For., Vol. I.)
[4] Hilgard: Tenth Census Report, Vols. V and VI.

at present doubtful. Its northern limit west of the Alleghanies can be described by a line drawn from the lower part of Wood County, in West Virginia, to Menifee County, eastern Kentucky. Beyond the wide gap covered by the deciduous forests of the lower Ohio Valley and the flood plain of the Mississippi the tree appears on the southeastern spur of the Ozark Hills in Cape Girardeau County, Mo., latitude 37° 30′, and on the opposite side of the river on the bluffs in Union and Jackson counties, Ill., the line dropping gradually half a degree southward to the western limit of its range. (Pl. XIV.)

The Shortleaf Pine is a tree of the plain and the foothills, in the South rarely ascending to an elevation over 2,300 feet, and at its northern confines not over 1,000 feet (in the Ozark Hills). East of the Mississippi River the tree appears sparsely scattered among the hard-wood trees; along the border of the Carolinian and within the Austro-riparian zone it becomes more frequent, and often the predominating tree. West of the Mississippi River the Shortleaf Pine finds its region of greatest profusion, forming forests of vast extent on the uplands of the undulating plain and the table-lands of the hill country, which in their timber wealth and economic importance rival the great lumbering regions farther south.

CHARACTERISTICS OF DISTRIBUTION IN DIFFERENT REGIONS.

On the Atlantic Coast, from southern New York to Virginia, judging from the statements of earlier writers, this tree must have formed originally a considerable part of the forests of coniferous evergreens covering the belt of light silicious soils of the Tertiary strata. A. Michaux mentions this species "as not found beyond certain districts in Connecticut, it being multiplied in the lower part of New Jersey, and still more on the eastern shore of Maryland and the lower part of Virginia." From the remarks of this writer on the extensive use of the timber of the Yellow Pine (Shortleaf) it appears that at the time of his writing—the beginning of this century—it must have been quite abundant in those parts.

This appears clearly by his statement that "in the Northern and Middle States (of the Atlantic Seaboard) and in Virginia, where, to a distance of 150 miles from the sea, all houses are built of wood, the floors, casings of doors, wainscots, and sashes are made of this species, as being more solid and lasting than any other indigenous wood. In the upper part of the Carolinas the houses are constructed wholly of Yellow Pine, and are covered with it." Further on we learn that immense quantities were used in the dockyards of New York, Philadelphia, and Baltimore, and that Yellow Pine lumber formed a considerable part of the exports to Great Britain and the West Indies. Since that time this tree has in the region mentioned not only long ceased to be a source of timber, but has generally become quite scarce. According to the information of Dr. N. L. Britton, "it grows on the coast of New York naturally only on Staten Island, and only about twenty-five trees are to be found in Richmond County. It is fairly abundant in the portion of New Jersey from the Raritan River to Delaware Bay, forming forests, on a tract not more than 8 miles, and it is also found in Delaware on the same formation outcrop of Green Sand."

With the appearance of the Longleaf Pine south of Virginia the Shortleaf Pine recedes from the coast and is found chiefly in the upper (interior) part of the Southern coast pine belt, scattered among the mixed growth of coniferous and deciduous trees. Above the upper limit of the Longleaf Pine belt the Shortleaf Pine extends, in the Southern Atlantic States, throughout the interior to the lower ranges of the mountain region.

West of the Alleghany Mountains, in western Virginia and eastern Tennessee, it occurs only widely scattered, and hence is practically of no importance to the lumbering industry.

In North Carolina the Shortleaf Pine is found from the coast to the mountains, though in the lower districts enters more rarely into the composition of the upland forests. According to Hale's report on the woods of North Carolina the tree is found in the majority of counties of the State, but is most abundant in the middle district, where, with upland oaks and hickories, it is the prevailing tree. It is found about Asheville, at an altitude of 2,500 feet. The Shortleaf Pine used to form 25 per cent or more of the forest growth in many places, but such areas are not now frequent anywhere. In the latest report on the forests of North Carolina[1] it is stated that there

[1] W. W. Ashe: The Forests, Forest Lands, and Forest Resources of Eastern North Carolina. Bulletin 5, Geol. Survey, N. C., 1894, page 41.

are possibly 300,000,000 feet, board measure, Shortleaf Pine standing in the counties bordering the oak uplands in the eastern part of the State.

In South Carolina this pine is similarly distributed sparingly in the coast region and more frequent in the midland country to the lower mountain ranges.

In Georgia, in the lower part of the coast pine belt, the Shortleaf Pine is rarely met with. On the sandhills in the center of the State, forming the northern border of the pine belt, it occurs mixed with the Longleaf Pine among the inferior hard-wood timber. In the region of crystalline rocks, which embraces the more or less mountainous upper half of the State, covering over 19,000 square miles, at an average elevation of about 2,500 feet, this tree is most frequent, in many parts predominating.

In the three States last named the Shortleaf Pine was originally most abundant in the regions now most densely populated, and hence their supplies of timber are more or less exhausted, much of the so-called North Carolina Pine sent to market being Loblolly Pine. Young forests, however, of this tree are seen everywhere on the hills and mountain slopes, where the original timber growth has been removed, and on the worn-out lands abandoned by the cultivator.

In Florida the Shortleaf Pine is confined to the uplands along the northern border of the State, scattered among the Longleaf Pine and hard-wood trees. In the northwestern part, it approaches the seashore within a distance of from 25 to 30 miles on the isolated patches of red loam lands, where, together with the Longleaf Pine, it is associated with the Southern Spruce Pine (*Pinus glabra*).

In Alabama and Mississippi the Shortleaf Pine is rarely seen in the lower part of the coast pine belt, but forms a more or less conspicuous part of the forest covering of the uplands in the central and upper sections, and sometimes predominates to such an extent over the hard woods as to impart to the woodlands the somber aspect of a pure pine forest. In the region of crystalline rocks, with its arid ranges in Alabama, covering an area a little over 3,000 square miles, between the Coosa River and the southern tributaries of the Tallapoosa, the tree is less frequent than in the region of the same formation in Georgia, the Longleaf here taking its place. In the northern part of Alabama, on the table-land of the Warrior coal field over an area of fully 5,000 square miles, mostly in forest, the Shortleaf Pine forms a more prominent feature of the growth. This is the case particularly in the eastern part of this area, where the tree occupies mostly the summits and steep declines with a thin, dry soil, while in the deeper and moister soils the Loblolly Pine takes its place. In Cullman County, altitude 800 feet, where numerous acre measurements have been made, rarely over 2,000 feet, board measure, of this timber have been found upon one acre, and it can safely be said that in the localities where it is more frequently met with the average stand does not exceed 1,500 feet to the acre on this table-land. The supplies of Shortleaf Pine timber are rapidly diminishing before the demands of a rapidly increasing population and of the adjacent centers of the mining industry, and their total exhaustion is sure to be effected within a short time.

Wherever the original timber growth has been removed on these uplands the young growth of the Shortleaf Pine is rapidly spreading and predominates over the deciduous trees. The timber trees of full growth average on these table-lands about 22 inches in diameter breast high and 95 feet in height, furnishing clear sticks of from 35 to 45 feet in length. Such trees have been found with from 90 to 135 rings of annual growth on the stump.

Four trees felled in the vicinity of Cullman showed the following dimensions:

Measurements of four trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings on stump.
Inches.	*Feet.*	*Feet.*	
22	42	101	109
21	41	75	111
20	40	87	132
24	45	92	120

On the gravelly hills of the northern extension of the central pine belt in Alabama the Shortleaf Pine becomes frequently the predominating tree in the forest of oak and hickory. In Lamar County, Ala., and in northeastern Mississippi it forms forests which in the latter State give

rise to a considerable lumbering industry. These forests are, however, rapidly decimated along the Memphis and Charleston Railroad, where the products of the mill find ready market throughout north Mississippi and at Memphis. Through the northern half of Mississippi, on the divide which separates the waters flowing into the Mississippi River from those of the Tombigbee, extends a region of undulating uplands of oak, hickory, and Shortleaf Pine over an area little short of 5,000 square miles; on this long, narrow belt the Shortleaf Pine can be said to form 12 to 15 per cent of the tree covering. These forests furnish an ample supply of pine lumber for local demands. It appears, however, that in the eastern Gulf States generally the existing supplies of Shortleaf Pine are scarcely sufficient to cover home demand. On these uplands the Shortleaf Pine takes rapid possession of the openings in the forest and the old fields. Here, as has been elsewhere observed in the central and northern parts of these States, this tree can truly be considered the timber tree of the future. Since it is rarely found in compact bodies, but associated with other trees widely scattered, any attempt at an estimate of the amount of the timber standing in these States must appear futile. The amount of timber cut can also hardly be approximated, since it forms only a part of the cut of the mills in these States.

West of the Mississippi River, north of the region of the Longleaf Pine, the Shortleaf Pine is found most abundant and in fullest perfection. It is in these Western forests that the Shortleaf Pine finds its best development, and forms pure forests, extending over many hundreds of square miles with but little interruption. The forests of Shortleaf Pine in northwestern Louisiana, Arkansas, southern Missouri, and northeastern Texas are scarcely surpassed in their timber wealth. The Tenth Census estimates the amount of merchantable timber of Shortleaf Pine standing in 1880 in these Western forests at 87,000,000,000 feet, board measure, exclusive of the forests in southern Missouri and the Indian Territory.

In Louisiana the Shortleaf Pine is unequally distributed over the uplands north of the Longleaf Pine region between the Ouachita River and the eastern boundary of Texas, embracing an area of a little over 8,000 square miles. Along the northern extent of the Louisiana and Texas State line this pine forms pure forests, and also prevails in many localities on the upland along the border of Arkansas. The resources of pine timber in these mixed forests of oaks, hickories, and Shortleaf Pine, removed as they are from the highways of traffic, have been but slightly drawn upon.

In Arkansas, in the hilly and mountainous region on both sides of the Arkansas River, over 19,000 square miles in extent, the Shortleaf Pine forms a large part of the tree covering of the siliceous rocky soil and frequently extensive forests on the wide table-lands. On the uplands of yellow loam south of the hills the tree predominates, especially on the low ridges of gravel and loam, the hard woods encroaching where the soil conditions become more favorable.

The low ridges rising above the Loblolly Pine forests of the flood plain of the Ouachita and Little Missouri rivers are covered with open forests almost exclusively of Shortleaf Pine, interspersed with a few White Oaks, Post and Spanish Oaks, rarely above medium size. In the vicinity of Gurdon, in Clark County, upon one acre representing average conditions, 22 Shortleaf Pines have been counted from 12 to 25 inches in diameter, with no pines of smaller growth among the scattered undergrowth of dogwood, huckleberries, scrubby oaks, Black Gum, and hickories. Of this number, 8 trees measured from 21 to 25 inches; 6 trees from 18 to 20 inches; 6 trees from 15 to 17 inches and 2 trees 12 to 14 inches in diameter breast high, indicating a stand per acre of about 6,000 feet, board measure.

Five trees, representing the average timber growth of the forest selected for timber tests, were found of the following dimensions:

Measurements of five trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings on stump.	Sapwood.
Inches.	*Feet.*	*Feet.*		*Inches.*
20	60	110	120	$2\frac{3}{4}$
24	47	106	132	$2\frac{1}{3}$
19	40	109	102	3
18	36	95	120	3
25	45	717	143	3

On the arid hills of flinty sandstone the trees are of inferior growth, as observed in Hot Springs County, in the vicinity of Malvern. On their steep slopes the pines are rarely found to exceed 18

inches in diameter breast high and 75 feet in height, clear of limb for the length of about 35 feet. In a number of trees from 120 to 125 rings were counted on the stump. The wood produced on these hills is of a lighter color, less resinous, and of a fine grain. Specimens of finished lumber from such timber resemble somewhat that of the White Pine. The hard-wood trees, mostly Spanish Oak and Post Oak, scattered beneath the pines, are scrubby and of no value for their timber.

Along the railroad lines the forests have become exhausted for a distance of from 5 to 10 miles on either side, and the timber from the virgin forests is conveyed to the mills on steam tramroads. It appears that of late years about 550,000,000 to 560,000,000 feet, board measure, of pine timber are sawn annually in Arkansas south of the Arkansas River. In this amount the Loblolly Pine lumber is included, which is indiscriminately sawn and put with the Shortleaf Pine on the market as Arkansas Yellow Pine. The bulk of the product of the sawmills in this section is shipped by rail to the markets of the Northwest.

In the northern part of Texas, east of the prairie region, from the Red River Valley to the northern border of the Longleaf Pine region (under latitude 32° N.), extends an area of oak, hickory, and Shortleaf Pine uplands, stated in the agricultural report as covering 35,000 square miles. In the southern extent of this area the districts where the Shortleaf Pine prevails are popularly known as the "Pineries." North of the Sabine River, from Longview through Cass and Bowie counties, the Shortleaf Pine forms compact forests over many hundreds of square miles. Near Bevins, in Cass County, where the pine forests were more closely investigated, the moderately dense timber growth covers the undulating country down to the lowlands of the Red River in Louisiana. The sandy gray loam forming the rather compact soil of the surface is underlaid by laminated stiff clayey marls, which at the depth of about 4 feet become quite impervious to water. Blackjack, Spanish Oak, and Post Oak of stunted growth are scattered beneath the pine. The pine appears to be of slower growth; trees of full size—that is, from 20 to 24 inches in diameter—were found to have reached an age of from 195 to 210 years. The upper part of the timber of such old trees is frequently affected by rot, a defect undoubtedly to be ascribed to the cold, impervious subsoil.

From 6,000 to 7,000 feet of merchantable timber are claimed as an average stand for these timber lands. Every tree above 10 inches in diameter at breast height is cut for the mills. After the removal of the pine the hard woods gain rapidly in the rate of their growth, soon shading the ground completely. Young pines are rarely seen in the natural openings, the seedlings being too frequently destroyed by fire. In the clearings, where the original tree growth has been completely removed and the pine takes quick possession of the ground, the second growth, if not killed outright by the fires which again and again devour the surrounding tall weeds and broom grasses, becomes too severely injured to be of any promise.

Four trees, selected as representing fairly the average merchantable timber of the Shortleaf Pine forests of northeastern Texas, showed the following record:

Measurements of four trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings in stump.	Sapwood on stump.
Inches.	*Feet.*	*Feet.*		*Inches.*
24	36	120	195	3
23	40	109	205	3
18	45	95	102	5½
17	42	94	102	5½

The forests of Shortleaf Pine near Longview, which was in 1880 the site of a most active lumber industry, have been nearly exhausted, and with diminished supplies along the New Orleans and Pacific Railway the business has greatly declined. The annual output of the 30 mills situated along this road, and its branch from Carthage to Panola, does not at present in the aggregate exceed 70,000,000 feet, board measure. From the information obtained in 1892 it appears that in 1891–92, 200,000,000 feet, board measure, were handled in Texarkana, the product of the mills at that place and immediate vicinity, and also that the shipments of the mills south of the Red River in the same year reached about 105,000,000 feet, board measure.

In Missouri the rugged hills and table-lands of the southern slope of the Ozark Mountains, rising to an elevation of from 800 to 1,000 feet, are covered with forests of Shortleaf Pine, which, roughly estimated, extend over little more than 3,000,000 acres. In the counties bordering on the Arkansas State line (Terry, Ozark, and Douglas counties) the pine is said to yield on the average not over 2,000 feet of timber to the acre. The forests in the basin of the Current and Black rivers are heavily timbered, as observed at Grandin. The density of the timber growth varies, however, on these broken lands with the soil conditions, a fact demonstrated by actual measurements on several plats, upon which the amount per acre varied from 3,000 to 15,000 feet of timber. After years of experience, the average yield of the timber lands of the Grandin Lumber and Mining Company is estimated at 6,000 feet of merchantable timber to the acre, including trees of 10 inches in diameter.

The trees felled to serve as material for the United States timber tests, and fairly representing the average timber growth, showed the following record:

Measurements of five trees.

Diameter breast high.	Length of timber.	Height of tree.	Rings on stump. *a*
Inches.	*Feet.*	*Feet.*	
31	40	103	174
20	50	99	150
17	35	92	140
22	40	88	180
24	50	109	218

a Sapwood on radius of stump averaging 2¾ inches.

The timber from these most northern of the forests of Shortleaf Pine is remarkably free from resin, of a fine, close grain, almost white, and claimed to be lighter and softer than the timber grown farther south, and like the timber occasionally found on the dry, rocky hills in Hot Spring County, Ark., resembling the wood of the White Pine. In these forests the fine tall pines tower high above the stunted Scarlet, Black, and White Oaks and hickories, but the growth of these hard woods almost completely overpowers the second growth of pine.

In close connection with the great markets of the North, and nearest to the timberless region of the Northwest, the manufacture of lumber in this region is fully developed. According to information received at Grandin, the output of the mills located along the Current River Valley Railroad, the Iron Mountain Railway, the Kansas City, Fort Scott and Memphis Railroad, and the Cape Girardeau and Southwestern road amounted for the year 1891–92 to fully 300,000,000 feet, board measure. At such rates the depletion of the timber wealth of this forest is to be expected before another generation has passed away.

Under the existing method of exploitation, which involves the almost total destruction of the smaller timber growth, nothing remains to be depended upon for the future. Considering the difficulties in the way of their natural renewal, there is no hope left for their restoration on these knolls. The dense undergrowth and brush of deciduous trees and shrubs which completely shade the soil, the rocky surface being hidden by an abundant and inflammable leaf covering, deprives the pine of every possibility of reproduction by natural seeding, even if the seedlings could escape destruction by fire.

According to the census of 1880,[1] extensive bodies of Shortleaf Pine timber exist in the eastern part of the Indian Territory. It occurs mixed among the hard woods on the higher ridges of the timber belt in the Choctaw Nation, 60 miles in length, and considerable bodies of Shortleaf Pine timber in belts of from 10 to 30 miles in length and 2 to 4 miles wide are found on the tributaries of Grand River in the Cherokee Nation, and in a large body of timber extending for 25 miles west of Ream this tree appears to reach its western limit.

The great importance of the forests of Shortleaf Pine to the industrial and commercial interests of the country west of the Mississippi River, and to the development of the adjacent timberless States and Territories, is forcibly exhibited by the enormous production of lumber for the past ten years. During the year 1891–92 at a low estimate not less than 1,270,000,000 feet, board measure,

[1] Report of Tenth Census, vol. 9, 1884.

have been shipped from points in Texas, Arkansas, and southern Missouri to Northern markets. This amount may be swelled by the production east of the Mississippi to round numbers of 1,500,000,000 feet, board measure.

As stated before, an estimate of the timber of this species standing is impossible on account of its scattered distribution and prevalent occurrence in mixed growths. But considering the extent of the areas within which it occurs and the average cut on the same, or comparing with the amounts of Longleaf Pine, which on account of the compact bodies in which it occurs, can be more readily approximated, it is safe to assume that very much less than 100,000,000,000 feet remain available, while the cut can be roughly estimated at 1,500,000,000 feet, board measure.

PRODUCTS.

Among the coniferous trees of eastern North America the Shortleaf Pine stands next to the Longleaf Pine in importance to the lumber industry and in the value of its timber. Freer from resinous matter, softer, more easily worked, not less susceptible of a good finish, the lumber of the Shortleaf Pine is often preferred by the cabinetmaker and the house carpenter to that of the Longleaf Pine. Less tenacious, and of less power of resistance under strain, it is principally used for the lighter framework in buildings, for weatherboarding, flooring, ceiling, wainscoting, cases for windows and doors, for frames and sashes of all kinds, and for shingles. Most of the dwellings located within the districts where this tree prevails are built almost entirely of Shortleaf Pine lumber, which bears ample testimony to its wide usefulness. It is also extensively employed in car building, for cross-ties, and in the manufacture of furniture.

NOMENCLATURE AND CLASSIFICATION.

This species, like all of the same genus of a decidedly Southern distribution in the Atlantic forest, belongs to the section *Pinaster* as defined by Engelmann, with cones of tough, woody scales their exposed ends thickened by an umbonate swelling (apophysis), which is armed with a weaker or stronger deciduous or persistent prickle or mucro. It was first described by Miller in the year 1768 as *Pinus echinata*,[1] and under that name recognized by the earliest writers on North American forest trees;[2] it was subsequently named by an obscure writer *Pinus virginiana*, var. *echinata*, Du Roi.[3] Michaux described this tree in his North American Flora[4] under the name of *Pinus mitis*, which received general recognition and by which it is known to botanists to the present day. *Pinus variabilis*, the name under which it was described at about the same time by Lambert,[5] was adopted by Wildenow, and following that author by Pursh, Nuttall, Elliott, and a few others of the writers on the botany of this country. In following strictly the rule of priority, at present most strongly advocated as the only measure to avoid further the confusion arising from an endless number of synonyms, *Pinus mitis*, the name under which it is generally known, will have to be abandoned, and the more obscure one, *Pinus echinata*, under which this species was first published, restored.

Great confusion is caused by the various appellations this tree has received in the English vernacular, being indiscriminately called Shortleaf Pine, Yellow Pine, and Spruce Pine, although most widely known under the first of these names, and in the markets it is now somewhat doubtfully established under the name of North Carolina Pine. In the States of the lower South it is frequently confounded with the Loblolly Pine, as the timber of the two is often, if not mostly, mixed. M. A. Curtis, in his "Trees of North Carolina," selected for this tree the name of Yellow Pine, strongly recommending its general adoption in order to introduce greater uniformity in the designations of our forest trees. Unfortunately the same name is in many of the Southern lumbering districts bestowed upon the Longleaf Pine, particularly when the timber is spoken of. It is often quite impossible to determine to which of the two species the timber is to be referred when under that name it is quoted in the reports of the lumber markets.

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[1] Miller's Dictionary, 8th ed., 1768: London.

[2] Marshall's Arboretum Americanum: Philadelphia, 1785.

[3] Du Roi Hb.

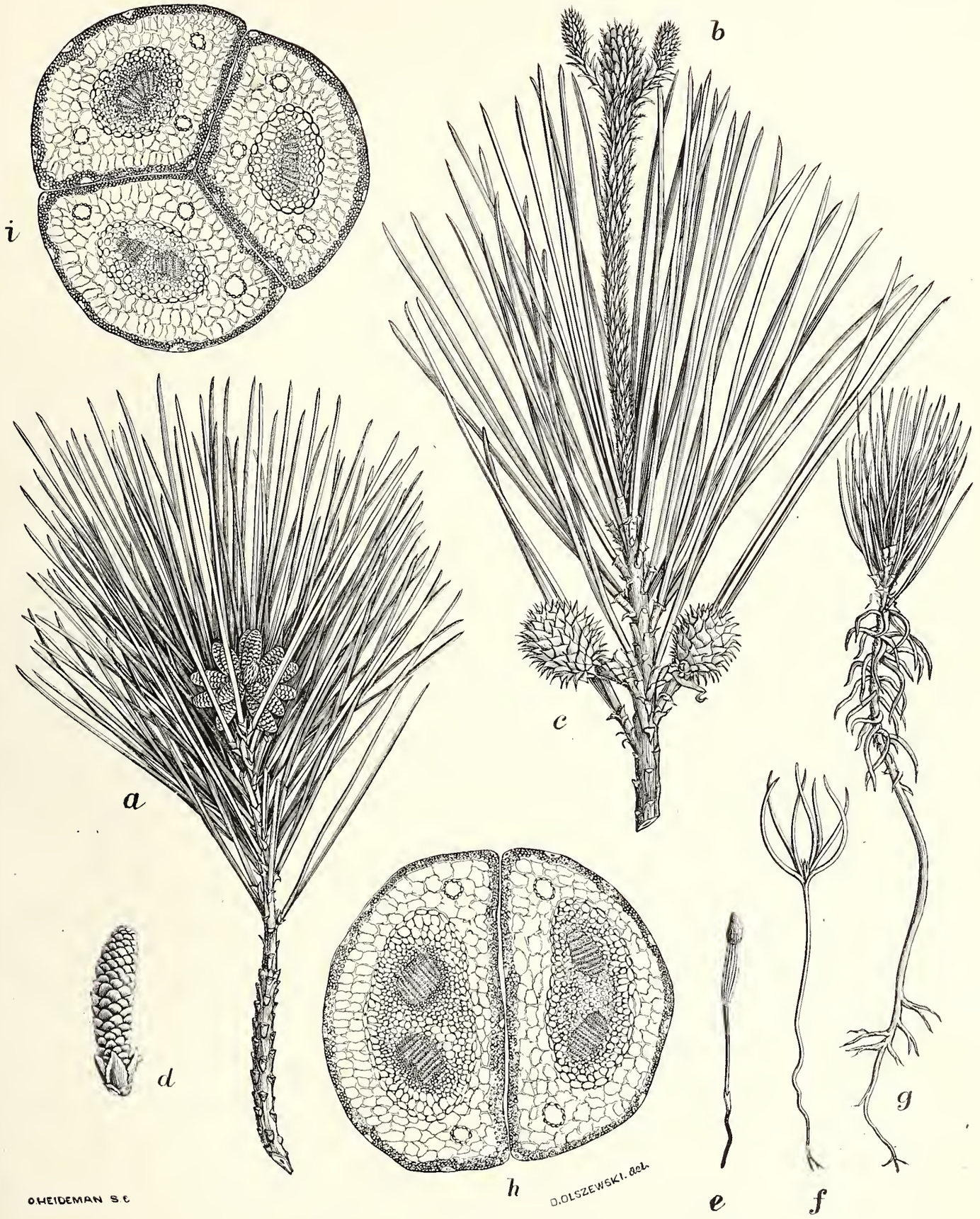
[4] A. Michaux's Flora Amer. boreal., Paris, 1803.

[5] Description of the Genus Pinus: A. B. Lambert, 1803 and 1824.

EXPLANATION OF PLATE XV.

[Figures natural size, except where otherwise noted.]

Fig. *a*, branch from a lower limb bearing male inflorescence with flowers in a dense cluster (first week of April, southern Alabama); *b*. *c*, branch with two subterminal aments of female flowers below which are two immature cones of one season's growth: *d*, detached male flower showing basal involucral scales, magnified 3 diameters; *e*, germinating seed (February): *f*, same seedling one month later (March) with 7 cotyledons in the midst of which the terminal bud shows the primary leaves appearing: *g*, seedling about the close of the first season with terminal cluster of true (secondary) leaves, below which are seen the withered primary leaves: *h*. *i*, transverse section through base of two and three leafed leaf bundle, magnified 50 diameters, showing outer small hypodermal cells, the stomata appearing as marginal white spots; next a broad band of large in-walled parenchymatous cells bearing chlorophyll, within which, at the angles of the leaf, resin ducts appear as large openings; the dark areas in the center are fibro-vascular bundles surrounded by a single row of thin-walled cells (bundle sheath).



PINUS ECHINATA: SEEDLING, MALE AND FEMALE FLOWER, AND LEAF SECTIONS.

Under the name of Spruce Pine, in the extreme Southern districts, it is invariably confounded with the true Southern Spruce Pine (*Pinus glabra*), the species which in several points it closely resembles and to which it is most closely related.

BOTANICAL DESCRIPTION.

Leaves mostly 2 (sometimes 3) in a short sheath, 3 to 5 inches long; cones 1½ to 2 inches long, oval or somewhat conical; scales with a short, tender, straight, and finally incurved prickle, light brown. Seeds rather small, two-fifths of an inch long, by one-tenth to one-eighth of an inch wide, with dark, scattered or confluent specks; the wings are reddish brown and about one-half of an inch long. The young shoots are of a glaucous violet color. The bark of mature trees is rather thick and broken up in squarish plates. The different general appearance of the tree will almost always serve to quickly distinguish it from the closely related Scrub Pine (*Pinus virginiana*) which is distinguished by its shorter and more rigid leaves. Any doubt can be removed by trying the twigs; those of the Scrub Pine are tough while those of the Shortleaf Pine snap off readily. The bark is of a light reddish brown color, and on the lower part of the trunk in full-grown trees three-fourths to fully one inch thick crossed by deep furrows, and flaky.

The limbs are arranged in more or less regular whorls, under full exposure, forming a crown with the outline of a truncated pyramid, by which the tree can be recognized from a distance and distinguished from kindred species with which it happens to be associated. The oldest and stoutest limbs are rarely over 20 to 25 feet in length, and are somewhat drooping.

It is indeed a beautiful tree, with its stately, gently tapering trunk and its finely shaped full crown clothed in an abundance of foliage, bearing the stamp of thrifty and vigorous growth.

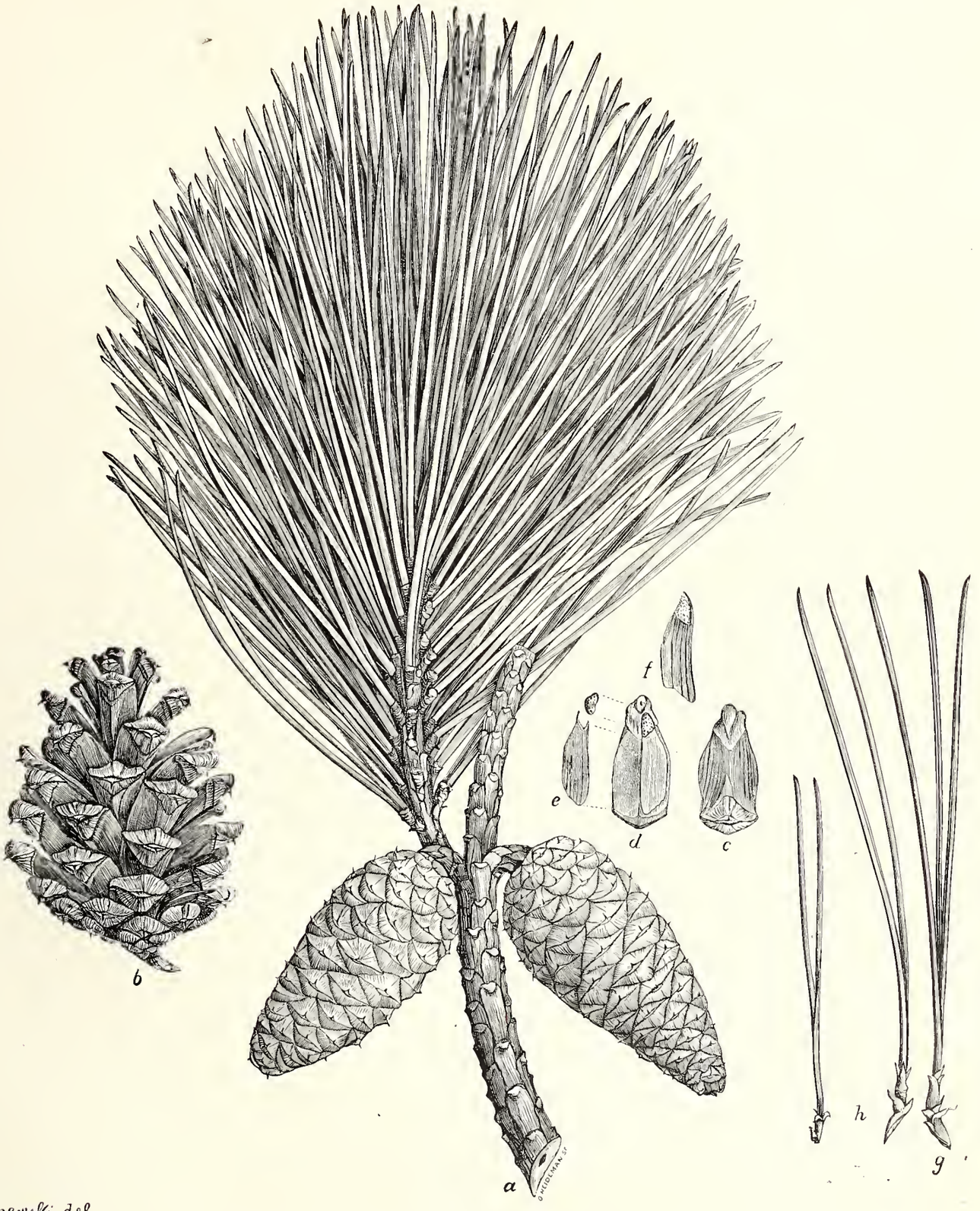
Leaves.—The secondary or foliage leaves are found mostly 2 in a sheath, and on shoots of vigorous growth often 3 are found in a bundle; occasionally whole trees are seen with 3 leaves in a sheath and in some rare instances on young trees even 4 have been counted (Pl. XVI, *g*, *h*). The leaves vary from 3 to 4 inches and a little over in length; they are slender, about one-eighteenth of an inch wide, strongly concave, slightly twisted, faintly serrulate, and abruptly sharp pointed, while young of a yellowish and later on of a deeper green color. In the cross section (Pl. XV, *h*, *i*) they present a semicircular outline; examined under the microscope they show on both sides about ten rows of minute stomata (breathing pores) the small epidermal cells underlaid by a single layer of rather thin-walled hypodermal or strengthening cells; in the specimens examined from 3 to 4 peripheral resin ducts were found, the bundle sheath consisting of a single row of cells. The sheath invests the leaves closely and rarely exceeds at any stages of growth three-sixteenths of an inch; the leaves are shed during the latter part of their second year.

The bract-like scales (Pl. XV, *b*. *c*.), modified primary leaves, which densely cover the young shoots and in the axils of which the foliage leaves are produced, are while young of a grayish color, closely appressed, lanceolate, acuminate, and fringed; with the subsequent development of the foliage leaves and the increase of the shoot in length, their tips become dried and are cast off. As the tender shoots become hardened they assume a glaucous purplish color.

Flowers.—The flower buds make their appearance during the latter part of the winter and begin, in stations of southern latitudes, to open near the end of March (Baldwin County, Ala., March 26), and farther north from three to four weeks later (Cullman, Ala., April 28). The staminate flowers are closely sessile, to the number of fifteen to twenty surrounding the terminal bud (Pl. XV, *a*), which at the time has scarcely grown to the length of an eighth of an inch. The staminal column, of a pale purplish color, does not exceed three-fourths of an inch in length, is less than one-eighth of an inch in thickness, and is surrounded by eight or nine decussate scales, those of the first pair being strongly keeled and scarcely half the size of the others (Pl. XV, *d*). The crest of the anthers is nearly circular and slightly denticulate. The male flowers are shed immediately after the discharge of the pollen. The female flowers are united in an oblong, obtuse, short-stalked catkin of a delicate rose-pink color, about one-fourth of an inch in length. They are rarely single, but mostly from two to four, produced closely below the apex of the youngest shoot (Pl. XV, *b*). The stipe of the catkin, not over three-eighths of an inch in length, is invested by twenty to twenty-four hyaline lanceolate, pointed, involucral scales, those immediately surrounding the flowers being widely spreading. The bracts subtending the carpellary scales cover the latter to the base of their long, subulate, erect tips.

EXPLANATION OF PLATE XVI.

Fig. *a*, branch with mature closed cones (October of second season); *b*, mature cone; *c*, cone scale, outer or dorsal view showing apophysis; *d*, ventral view of the same with seed in place; *e*, seed detached from wing; *f*, seed with wing intact; *g*, leaf forms, two and three leafed bundles.



D. Olszewski del

PINUS ECHINATA: CONE, SEED, AND LEAVES.

After fertilization has taken place the shoots bearing the fertile flowers increase rapidly in length. Fertile catkins are frequently found on the older branches, produced on branchlets from adventitious buds. The tree begins to produce flowers when from ten to twelve years old, according to exposure; male flowers have been observed one or two seasons earlier.

Cones.—Every season cones are produced in great abundance. The conelets of the first year, borne on a short, horizontal stalk, are oval in shape, scarcely one-half an inch in length, the squarrose tips of the scales giving them the echinate appearance from which the botanical name first given to this species was undoubtedly derived (Pl. XV, *c*).

Fully matured by the end of the second year, the cones are nearly sessile, oval, of dull or leather brown color, 1½ to rarely 2 inches long, and when open, nearly as wide; they are frequently smooth (Pl. XVI, *a*, *b*). The scales are hard, with a slightly swelled apophysis, devoid of or armed with the weak, more or less deciduous prickle (Pl. XVI *c*, *d*). The cones open early in the fall, and remain, after the discharge of their seeds, for several years on the branches. In consequence, the older trees are covered with them through all seasons.

Seed.—The Shortleaf Pine produces seeds in greatest abundance; its crops seem never to fail. The seeds are small, triangular, three-sixteenths of an inch long by one-eighth of an inch wide, the hard, roughish testa marked with three indistinct ridges and more or less with confluent specks; the wing is of a light, reddish brown, half an inch in length and deciduous during germination (Pl. XV, *e*, *f*). The seeds retain their vitality for several years; fresh, they will germinate in from ten to fifteen days. The number of seeds to the ounce is about 5,000; wafted by the wind over wide distances and germinating early during the first days of spring, their offspring are found to take possession of every opening in the forest and of the old fields in localities favorable to their growth.

THE WOOD.

The wood of Shortleaf Pine resembles that of the Loblolly in almost every respect. The sapwood is clearly defined, being quite broad, and even in very old trees forms fully one-half of the total volume of the trunk. In thirteen trees one hundred to one hundred and fifty years old, the average width of sapwood was found to be about 4 inches, while even in trees over one hundred and fifty years old its average width was 3 inches. In the former case, the sapwood formed 65 to 70 per cent of the volume of the logs; in the latter, 50 to 55 per cent, while in a set of trees fifty to one hundred years old it formed fully 80 per cent of all the wood. The change from sapwood to hardwood proceeds much as in Loblolly Pine. It begins when the tree (or any disk) is about twenty-five to thirty years old, and is retarded more and more with age, so that in old trees as many as eighty or even one hundred rings are counted in the sapwood, while in young and thrifty trees not more than thirty to forty may occur.

In keeping with the large amount of sapwood, the weight of green Shortleaf Pine is rather great, varying, for entire logs, from 45 to 55 pounds per cubic foot, commonly approaching 60 pounds in the largely water-filled outer portions of the sapwood.

When kiln-dried, the wood of trees one hundred to one hundred and fifty years old weighs on the average about 32 pounds per cubic foot. As in other pines, the butt is 15 to 20 per cent heavier than the top, and the wood of the inner forty to fifty rings excels in weight and strength the wood of the outer parts of old logs. As was stated for Loblolly, the sapwood may be light, heavy, weak, or strong, according to the age of the tree from which it is obtained. As might be expected from the great range of distribution of this tree, its wood, like that of Loblolly, varies within very wide limits. Specimens from Missouri (near its northern limits) are generally lighter and less resinous than those from farther south, and frequently resemble the wood of the Norway Pine, while many select specimens from the Gulf and South Atlantic States rival in weight and strength the best grades of Longleaf Pine. In its strength, as in its weight, the Shortleaf follows Loblolly Pine.

The average of a large series of tests furnishes the following average values for dry pieces of this species:

	Lbs. per sq. inch.
Modulus of elasticity	1,600,000
Transverse strength	9,230
Compression endwise	5,900
Shearing along the fiber	688

As the average weight of this series was 38 pounds per cubic foot, or about 16 per cent heavier than the average weight involving all parts of all the trees. these figures should be reduced by that per cent to represent the true average for the wood of the species.

In drying, 100 pounds of wood lose from 40 to 50 pounds of water, the bulk of which comes from the sapwood, which contains 60 per cent and more. while the heartwood, like that of most pines. contains about 25 per cent.

The shrinkage in volume consequent on drying amounts to about 11 per cent. It is about 13 per cent in the wood of the butt and about 10 per cent in that of the upper logs, varying in this respect directly as the weight of the dry wood. Of the 11 per cent, about 8 per cent fall to the tangent or occur along the rings and 3 to 5 per cent along the radius.

The structure of the wood of Shortleaf Pine is essentially the same as that of Loblolly. Summerwood and springwood are sharply defined. The proportion of the former to the wood on the whole varies. as in Loblolly, in the same manner as the weight of the wood, being greater in the butt than top. greater in the wood of the inner rings than in the wood farther out, and greatly reduced in all cases where the growth of the tree is suddenly retarded by unfavorable seasons, but is otherwise quite independent of the width of the rings.

For details of structure, consult the comparative study of Mr. Roth, appended to these monographs.

PROGRESS OF DEVELOPMENT.

The seeds begin to swell and to germinate in the early days of spring. In Mobile County, on the end of the first week of March, the plantlets had their cotyledons fully unfolded, which were found to vary from six to seven in number, with the lower (hypocotyledonary) part of the axis from 1½ to 2 inches long, the rootlets being somewhat less in length (Pl. XV, *c. g*). The development of the upper part of the axis (caulicle) from the terminal budlet and of the primary acerose leaves proceeds now rapidly. These primary leaves succeeding the cotyledons are stiff and spreading. about three-fourths of an inch long and covering the stem densely (Pl. XV, *g*), remain during the first season, withering from below during the warmer part of the season. By the close of the first season the caulicle or first shoot has attained a length of from 3 to 4 inches. On the shoot of the second season (rarely before) the secondary leaves, which constitute the foliage, make their appearance from the undeveloped branchlets in the axis of the primary leaves (Pl. XV, *g*). At the end of the second year the plants are 7 to 8 inches high. with a taproot 2 to 3 inches long. During this season adventitious buds appear at the collar of the stem. which bring forth vigorous sprouts, particularly if the stem has sustained the slightest injury. These shoots are covered with primary leaves, which are retained for one season. They are apt to form strong branches before the tree has reached its fourth or fifth year; such branches, which are produced profusely from the stumps of larger trees, scarcely survive another season. It is rarely that branches are produced in the second year, the first branches appearing generally in the third season in whorls of three to four. In the third year foliage leaves alone are produced in the axils of scales with their bases close to the stem. At the close of the third year the plants are from 12 to 18 inches high. Now the development of the root system advances rapidly, the taproot being by this time about 8 or 10 inches long, with strong lateral roots often double that length. Both taproot and lateral roots are finally vigorously developed, penetrating deep into the ground, so that trees of this species are rarely blown down by winds. At the end of the fourth year the plants are from 2 to 3 feet high. with the stem at best from five-eighths to seven-eighths of an inch thick.

The branches of the whorls begin now in their turn to develop branchlets in whorls of secondary order. The development of the primary axis and its branch system proceeds henceforth in the regular acropetal order. As in all pines, the shoot of the main axis takes the lead in rapidity and vigor of growth. By a number of measurements made at Cullman, north Alabama, of trees from the openings in the forest, as well as from clearings, it was found that by the end of the fifth year they had attained a height varying between 3 and 5 feet, rarely over, the stem being from five-eighths to seven-eighths of an inch in thickness; by the end of the sixth year, from 6 to 9 feet high and from one-half to 2 inches in diameter; and at the tenth year, from 10 to 16 feet high and from 2

to 2½ inches in diameter. At the age of fifteen to twenty years, with a total height of from 20 to 30 feet and a diameter breast high of 4 to 5 inches, the crown of the tree occupies from one-half to five-eighths of its height. Henceforth throughout the period of quickest growth its rate is greatly influenced by conditions of light and soil. At the age of fifty years the height of the trees varies between 40 and 60 feet and the diameter breast high between 10 and 14 inches. About this age, or perhaps a short time before, the height growth begins to decline and the branches become somewhat reclining below and spreading toward the top, and consequently the head of the tree becomes more rounded in outline. Between the ages of sixty and seventy years the trees are from 50 to 70 feet high and from 12 to 15 inches in diameter, with the trunk clear of limbs for 30 to rarely over 40 feet. From this period on the growth proceeds at a slower rate. On reaching its one hundredth year the tree has attained a height between 90 and 95 feet and a diameter of from 16 to 19 inches at most. Having now passed its period of vigorous life, the growth is henceforth insignificant. Between the ages of one hundred and twenty and one hundred and thirty years trees were found 90 to 110 feet high and from 18 to 24 inches in diameter. The oldest tree encountered in the measurements, with two hundred and eight rings of annual growth in the stump, scarcely exceeded 109 feet in height and measured 24 inches in diameter. The largest tree felled was 117 feet high and 25 inches in diameter, with one hundred and forty-three rings in the stump. Occasionally trees are found of a diameter exceeding 3 feet, but such are exceptional.

TABLE I.—*Growth of Shortleaf Pine (Pinus echinata), from eight to fifty years.*

Number of tree.	Rings in stump.	Diameter at breast high.	Height to first limb.	Total height.	Locality.	Remarks.
		Inches.	*Feet.*	*Feet.*		
1	8	2	6	11	Cullman, Ala	Clearing made in 1879 for pasture in dense pine thicket.
2	8	2	.....	11	....do	Do.
3	9	1¾	.....	11	....do	Do.
4	10	2¾	.....	17	....do	Rocky hillside, border of thicket.
5	10	2½	.....	11	....do	Rocky hillside in dense thicket of vigorous growth; youngest shoot, 19 inches.
173	12	2¼	7	11	Bivins, Tex	Exposure free in opening of forest.
138	11	2	7	11	Grandin, Mo	Rocky table-land; opening in forest.
9	12	3	.....	20	Cullman, Ala	Border of thicket; freely exposed.
137	12	2	.....	16	Grandin, Mo	Rocky table-land; partially exposed; in forest.
6	12	2	10	19	Cullman, Ala	Exposed; border of woods.
5	13	2¼	6	16	....do	Do.
7	13	2½	.....	17	....do	In midst of thicket; old clearing.
10	13	3	.....	20	....do	Old pasture, cleared in 1879; most vigorous growth; young shoot 19 inches.
8	15	4	12	24	....do	Do.
136	15	4	10	20	Grandin, Mo	Rocky hills; open forest.
171	18	4	15	36	Bivins, Tex	Open forest.
159	19	4	22	37	Gurdon, Ark	Exposure free; open grove of second growth.
135	19	4	10	20	Grandin, Mo	Oppressed in forest opening by oak scrub.
134	20	6	14	26	....do	Rocky; open woods.
161	19	2½	8½	25½	Gurdon, Ark	Open grove; closely oppressed.
160	22	3	12	25	....do	Open grove of second growth.
157	27	6½	12½	25½	....do	Do.
138	24	3½	22	33	....do	Do.
170	25	4	15	34	Bivins, Tex	Partially free; in forest.
155	41	11	51	70	Gurdon, Ark	Free; old field.

TABLE II.—*Growth of Shortleaf Pine during stage of rigorous growth, from fifty to one hundred and twenty years.*

Number of tree.	Rings in stump.	Diameter— At breast high.	Diameter— Below crown.	Height to first limb or crown.	Total height.	Length of timber.	Locality.	Remarks.
		Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
169	52	6½	.....	22	46	.....	Bivins, Tex.	In forest; soil cold, underdrainage deficient; exposure free.
168	58	6¼	.....	20	50	.....	do	Exposure free; opening in forest.
	60	15	.....	45	81	.....	Baldwin County, Ala., near Tensaw River.	Coastline; loamy sand, with Cuban Pine; exposure free.
167	73	12	.....	38	89	32	Bivins, Tex.	Opening in forest; exposure partially free.
165	102	16½	.....	62	94	.....	do	Oppressed.
164	102	18	.....	45	95	.....	do	
152	102	19	.....	38	109	38	Gurdon, Ark	Exposure free; open forest.
	105	15	.....	32	64½	30	Cullman, Ala	Partially free on gravelly ridge.
	109	22	.....	42	101	40	do	Exposure partially free; open forest; dry hill; sandy, gravelly loam.
31	111	21	.....	41	74	.....	do	Exposure free; gravelly loam.
166	114	17	.....	46	93	46	Bivins, Tex.	Oppressed on all sides; red heart above 36 feet.
1	116	22	19½	45	93	42	Cullman, Ala	Exposure free; open forest; rocky, and sandy loam.

TABLE III.—*Growth of Shortleaf Pine during stage of slow growth, latest stage of life.*

Number of of tree.	Rings in stump.	Diameter— At breast high.	Diameter— Below crown.	Height to first limb or crown.	Total height.	Length of merchantable timber.	Locality.	Remarks.
		Inches.	*Inches.*	*Feet.*	*Feet.*	*Feet.*		
	120	24	.....	45	92	42	Cullman, Ala	Open forest; hills; soil, sandy clay; exposure free.
150	120	20	13	73	110	60	Gurdon, Ark	Open forest; gentle declivity; gravelly clay.
153	120	20	.....	47	95	45	do	Do.
150*a*	132	24	19	47	106	43	do	Do.
	132	20	.....	42	87	40	Cullman, Ala	Open forest; clay hill; exposure free.
129	140	17	12	39	92	38	Grandin, Mo	Exposure free; rocky table-land.
154	143	25	20½	46	117	45	Gurdon, Ark	Exposure free; gravelly hillside.
128	150	20	.....	50	100	50	Grandin, Mo	Rocky table-land; exposure free.
127	174	31	.....	46	102	40	do	Do.
130	180	22	.....	42	91	40	do	Rocky table-land; exposure partially free; slightly suppressed.
162	195	24	.....	37	119	37	Bivins, Tex.	Cold soil; exposure free.
163	204	23	.....	61	108	40	do	Cold soil; exposure free; affected above 40 feet with red heart.
131	218	25	22	55	110	50	Grandin, Mo	Exposure free; soil loamy, deep.

From the general table (No. IV) and the corresponding diagram it seems that in the average the tree at twenty is about 30 feet high, reaches 50 feet at the age of forty, and that its growth in height is in the main finished at the early age of 70. In keeping with this, the growth in diameter is quite rapid during the first fifty years, continues at a moderate pace up to 80, when the age of extreme slow growth is entered.

TABLE IV.—*Rate of growth of Shortleaf Pine.*

Age.	Diameter with bark (breast high).	Length of log with upper diameter of 5 inches.	Total height of tree.	Volume.		Periodical growth by decades.					Average annual accretion.	Current accretion.
				Tree.	Log up to 5 inches diameter.	Decade.	Diameter.	Height.	Area of cross section.	Volume.		
	Inches.	*Feet.*	*Feet.*	*Cu. ft.*	*Cu. ft.*		*Inches.*	*Feet.*	*Sq. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
10	3.0	.....	11	0.32	.....	First	2.2	11	0.03	0.32	0.03	0.03
20	5.2	.....	27	2.21	.....	Second.....	2.3	16	.07	1.89	.11	.19
30	7.4	15	41	7.55	6.37	Third.....	2.2	14	.14	5.34	.25	.53
40	9.3	26	51	14.06	12.98	Fourth	1.6	10	.13	6.51	.35	.65
50	11.0	38	60	22.18	21.18	Fifth	1.6	9	.17	8.12	.44	.81
60	12.7	48	67	31.97	31.10	Sixth	1.6	7	.21	9.79	.53	.98
70	14.5	56	71	43.96	43.32	Seventh	1.6	4	.21	11.19	.62	1.20
80	16.0	61	75	56.54	55.91	Eighth	1.5	4	.23	12.58	.70	1.26
90	16.5	64	78	62.53	61.89	Ninth	.6	3	.10	5.99	.69	.60
100	17.0	67	81	67.68	67.05	Tenth	.5	3	.07	5.15	.68	.51

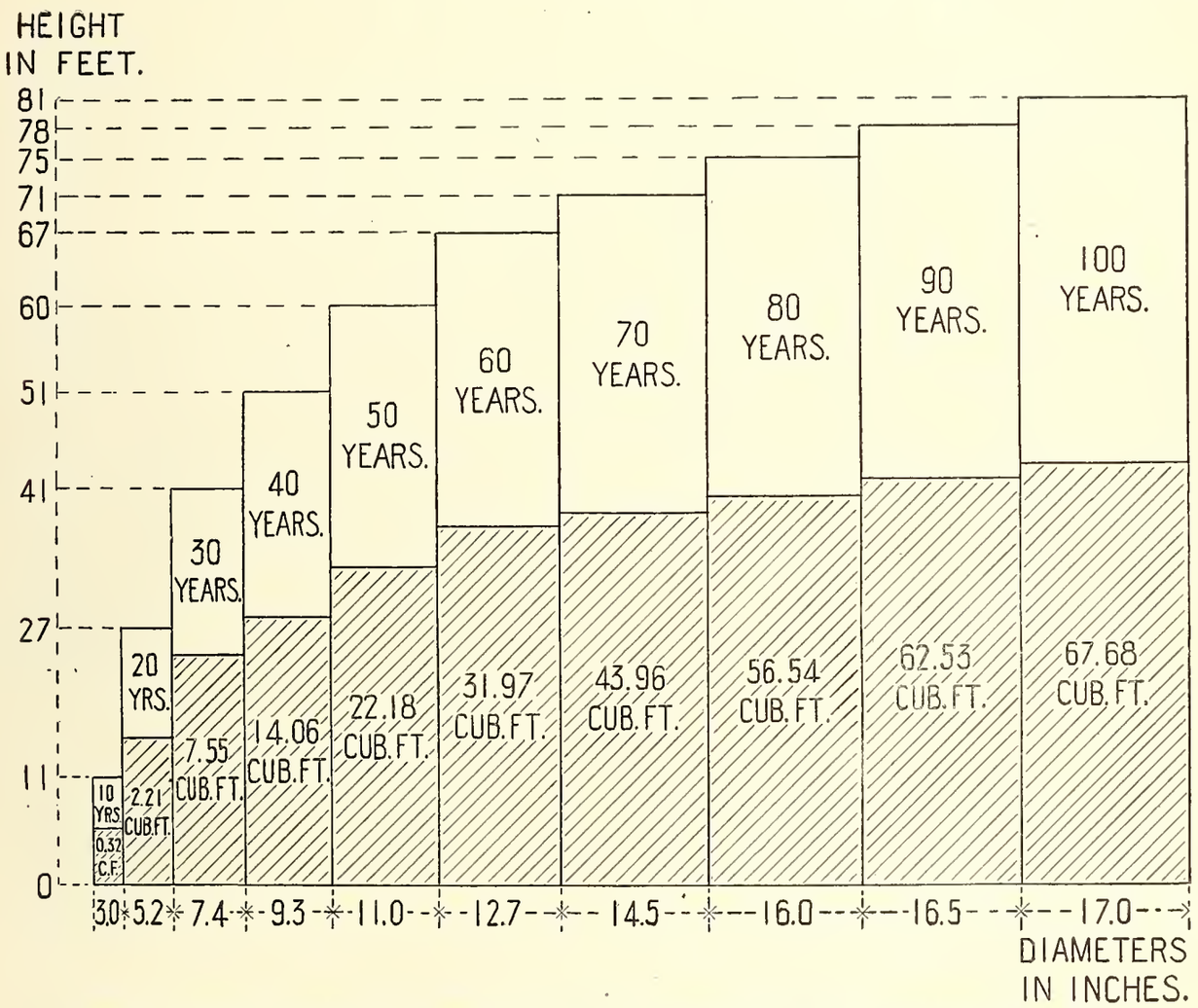


FIG. 11.—Growth of Shortleaf Pine: Height, diameter, and cubic contents of average trees at 10, 20, etc., years of age.

CONDITIONS OF DEVELOPMENT.

Soil and climate.—The Shortleaf Pine prefers a well-drained, light sandy or gravelly clay soil or warm loam, even if deficient in the elements of plant food. Soils of this character which are found widely prevailing over the undulating or broken uplands, if only of sufficient depth, will produce this tree in greatest perfection. It avoids the strongly calcareous and the rich alluvial soils, as well as purely silicious, being dependent on the presence of a certain amount of clay by which the mechanical condition of the soil is improved, rendering it more compact and more

retentive of moisture. That a purely sandy and highly porous soil is not favorable to this tree is shown by the stunted growth of the waifs sometimes found in the openings of the forests of Longleaf Pine on the sandy, arid uplands in the lower part of the coast pine belt.

Distributed in its range over 10 degrees of latitude and exposed to wide differences of temperature, it shows almost the same thrift of growth near its northern limits under the isotherm of 50° F., and in regions where the thermometer falls to near 20° below zero, as in lower latitudes with a mean annual temperature of 64° F. It can, therefore, endure a considerable range of temperature.

The conditions of atmospheric moisture evidently exercise a much more decided influence over its distribution, and, without doubt, upon its individual development. The tree is found in greatest abundance and of best growth where, within the limits of its distribution, the annual rainfall varies between 48 to 52 inches, it is less frequent in the districts where the precipitation exceeds 56 inches, still scarcer where the annual rainfall averages below 44 inches, and entirely wanting where this is less than 40 inches. Hence it is found best developed in the upper part of the Gulf States and west of the Mississippi River in adjacent northern districts from the interior of Georgia to northeastern Texas, where the most favorable conditions in regard to atmospheric precipitation prevail. The tree seems to avoid the humid air of the coast along the Gulf, as well as along the seashore of the Southern Atlantic States, nor does it ascend the mountains in these States above an altitude of 2,500 feet.

RELATION TO LIGHT AND ASSOCIATED SPECIES.

The Shortleaf Pine, like most pines, is a light needing species, being, however, less sensitive to a deficiency in this direction than the Longleaf and Cuban pines, which latter succumb in competition with the Shortleaf Pine. Originally the Shortleaf Pine is found more or less associated with various oaks (Spanish Oak, Blackjack, Scarlet Oak, Post Oak, and Black Oak), the Mockernut and the Pignut Hickory, and more rarely with the Chestnut, the Mountain Oak, and the Scrub Pine. All of these species prefer the warm, lighter soils of the uplands. These companions of the Shortleaf Pine are joined in the lower Southern States by the Loblolly and Longleaf Pine. Wherever in these upland forests an opening is made the Shortleaf Pine gains over its associates, finding its only successful rival in the Loblolly Pine. It is in the Southern States proverbial that in the upland forests "the pine is crowding out the hard-wood timber," a fact early observed. The displacement is effected either gradually in the course of time, or instantly when the removal of the original timber growth has been sudden. In the upper part of the maritime pine belt, where it is associated with the Longleaf Pine, the latter is sure to be replaced by the Shortleaf species, often joined in the course of such invasion by the Loblolly Pine.

ENEMIES.

Little is known of the fungoid parasites and of the insects endangering the life of the Shortleaf Pine. From my own observation, it seems that this tree is less affected by the former than the other pines of the same region. In the lumbering districts of Alabama a disease called redheart or redrot, caused by the mycelium of a large species of Polyporus, which is so highly destructive to the Longleaf Pine, is in this species almost unknown. In northeastern Texas this disease was found to affect the superannuated timber trees, which were over two hundred years old. According to A. S. Packard[1] the hosts of insects affecting this pine seriously are scarcely less in number than those infesting the Longleaf Pine; its enemies belong to the same or very nearly related kinds. Among the borers the *Monohammus confusor* and other species of the same genus dig burrows in the timber to the heart; the larvæ of numerous *Buprestidæ*, *Cerambicidæ*, and *Curculionidæ* burrow under the bark, and the *Tomicus calligraphus*, *cacographus*, *cicelatus*, and other species of *Scolytidæ*, at certain seasons are in immense numbers carrying on their work of destruction in the cambium layer, leaving in wonderful delineation on the inside of the bark the marks of their pernicious activity and causing the speedy death of the tree.

Mr. E. A. Schwarz, of the Division of Entomology, Department of Agriculture, remarks in this connection that of more than usual interest is the remarkable and disastrous invasion of one of

[1] A. S. Packard: Insects injurious to forest and shade trees.

these bark-boring Scolytid beetles (*Dendroctonus frontalis*), which in former years was universally considered a rare species. This invasion started in 1888 from the mountainous regions of West Virginia and within four years spread throughout the Alleghany Mountains and adjacent lowlands from Pennsylvania to the Carolinas. The amount of damage caused by this beetle within that time to the Shortleaf Pine and other pine trees has been enormous. A contagious disease, probably of a fungoid character, terminated in 1892 this invasion just as suddenly as it had commenced, and in 1893 not a single living beetle could be found throughout the infested region. The white froth hiding the larva of a tree jumper (*Aphrophora parallela*) is very common on the summits of the twigs, the larvæ of the sawflies are seen at the same season to feed on the tender, young foliage, which is also infested by a small white Gelechia depositing its eggs on the leaves, the larvæ boring into them to provide shelter for their pupæ; and according to Mr. Schwarz the leaves of the Shortleaf Pine are frequently found completely covered by a scale insect (*Mytilaspis pinifoliæ*), causing what is termed in New England the "white malady" of the pine. Of the flat-headed borers, larvæ of the *Buprestidæ*, the most injurious species are *Chrysobothris dentipes* (Germ.), *Calcophora virginiensis* (Drury); less common, *Calcophora georgiana* (Lee.) and *Buprestis lineata* Fab. (Schwarz).

Exposed to the same dangers of destruction by forest fires and by live stock of every kind, which threaten the Longleaf species with extermination, the chances of this pine to resist them and to escape such eventually are more favorable in consequence of the greater facilities for its reproduction and of its rapidity of growth during the earliest stages of its existence.

The pernicious influences of the first of these agencies is, however, painfully visible near the settlements where the forest is exposed to its effects one season after another. In such localities the pines are of stunted growth; in the middle stage—their very prime of life—they exhibit signs of decay and early death. But few of the younger trees exposed to fire were found on close examination to be free from defects and marks of impending disease.

Confined to the gentle slopes of the low hill country, to rolling uplands, and to broad table-lands, this tree is scarcely exposed to destruction by torrents and floods. Unsought for its resinous juices, it is not subjected to the wholesale destruction caused by the prevalent methods employed in the manufacture of naval stores. No other timber tree found in the southern portion of the Atlantic forest region is more easy of natural reproduction than this species throughout the wide range of its distribution. This is readily accounted for by its great fecundity, the seeds produced in great abundance almost without failure every year being profusely spread far and wide, and germinating easily wherever the proper soil and a chance is offered for their reception. By their thrifty growth the seedlings soon gain the upper hand over the contemporary growth of other species.

Throughout the interior of the Atlantic and the Gulf States tracts of upland, originally covered with fine oak forests, which had been cleared for cultivation and but little over half a century ago abandoned, are found at present occupied by the Shortleaf Pine, forming dense groves of trees 65 feet and over in height, with a diameter of 10 to 12 inches, standing 18 to 20 feet apart, with no undergrowth whatever.[1] Such young forests, met with in every stage of growth, afford highly instructive lessons of the ways taken by nature in the spontaneous restoration of the forest. In such spontaneous growths of the Shortleaf Pine the saplings form from the first mostly dense thickets. Before having arrived at their tenth year the work of thinning has actively begun by the death and speedy decay of the weakest. Thus favored by the access of light and air, the surviving trees shoot rapidly upward, the most aspiring individuals spreading out their crown, overshadowing those lagging behind, which being thus cut off from the influences above all others required for their existence, one after another die. Before the trees have reached the middle stage of their growth the stand of timber in the young forest appears to be firmly established, and during the following period, embracing less than half a century, they have attained the fullness of their growth, furnishing timber fully matured and of the dimensions and quality required by the present standard. Unchecked by destructive influences the rotation of a crop of timber of the Shortleaf Pine produced without the interference or assistance of man, can be said to be accomplished within a period of from eighty-five to ninety-five years.

[1] Charles Mohr: Proceedings of the Fourth Annual Meeting of the American Forestry Congress, Boston, September, 1885.

FOREST MANAGEMENT.

From the place this species is taking among the second growth it can be safely predicted that it is destined to be the timber tree of the future, as far as the Southern States of the Atlantic forest region north of the Longleaf Pine belt are concerned. It is upon this tree that in this section succeeding generations will have to depend for their supplies of pine timber of superior quality, and in which the nearest substitute is to be found for the supplies furnished at present by the Longleaf Pine. That the resources of the latter under the increasing strain to which it is subjected will be completely exhausted before its restoration can be effected is too evident to admit of any doubt.

Among the timber trees of the coniferous order found in the Atlantic forests, there is, then, scarcely a species presenting stronger claims to the attention of the forester than the Shortleaf Pine. As far as its demands upon climate and soil are concerned, it is capable of successfully establishing itself over the immense territory reaching from 30° to 38° north latitude and from the Atlantic Slope to the treeless plains of the West, embracing within these limits areas of wide extent, with all the conditions required for the best development of this species, and in great measure adapted to nothing better than the growth of timber. Of not less importance than its value as a timber tree are its facilities for natural renewal, resulting from the abundant crops of seed produced almost without failure every year and its aggressive behavior toward competing species in the successful struggle for the possession of the soil.

From a closer observation of the young forests of spontaneous growth at different stages, it is apparent that in the establishment and rearing of a forest of Shortleaf Pine, where mother trees exist, nature requires comparatively little assistance from the hands of the forester, and that the efforts of the latter will be chiefly confined to measures of protection against destruction by fire and against the injuries caused by inroads of live stock during the earlier stages of growth. That by thinning out, practiced after the first to the middle or end of the third decade, the forest growth would be benefited, there can be but little doubt. To what extent, by such interference, the production of merchantable timber can be promoted and in quantity and quality improved at the least cost remains a matter of future experiment. In the total absence of facts, based on experiment, no suggestions can be offered on these points other than such as can be deduced from the natural requirements of this species, as already discussed.

In conclusion, it can be safely asserted that the Shortleaf Pine is destined to take a prominent place in the forest management of the future throughout the regions favorable to its growth, not only on account of its economic value in the natural forest, but also in holding out better prospects to the forest planter for the production of timber of higher quality in the shortest time than any tree of the same order in the Southern Atlantic forest region. That the methods of a rational forest management will have to be resorted to at no distant time can with certainty be predicted, although the timber wealth existing at present in the vast territory of its growth may appear enormous.

Of great importance in the reforestation of large areas, this tree is of no less significance to the farmer who is aware of the advantages resulting from the restoration of the tree-covering on his denuded uplands, either originally unfit for profitable tillage or thrown out of cultivation after their exhaustion. By the facility of its natural renewal the Shortleaf Pine affords within a short time a firm protection to the light soil, preventing it from being carried away by wind and rain, providing a shelter for the crops and for insectivorous birds, a lasting income of increasing supplies of timber and fuel on lands that yield no other profit whatever, and to the lands abandoned after their exhaustion a chance for their recuperation while resting under the cover of its shade.

LOBLOLLY PINE (PINUS TÆDA).

THE LOBLOLLY PINE.

(PINUS TÆDA Linn.)

History and Distribution.
Products.
Description, Botanical.
Description of Wood.
Progress of Development.
Conditions of Development.
Reproduction.

THE LOBLOLLY PINE.

(*Pinus tæda* Linn.)

Synonyms: *Pinus tæda* Linnæus, Spec. Pl. ed. 1, ii, 1000, excl. habitat "*Canada paludosis*" (1753).
Pinus tæda var. tenuifolia Aiton, Hort. Kew. ed. 1, iii, 368 (1789).
Pinus tæda Rafinesque, Flor. Ludovic. 162 (1817), *nomen nudum*.

COMMON OR LOCAL NAMES.

Loblolly Pine (Del., Va., N. C., S. C., Ga., Ala., Fla., Miss., La., Tex., Ark.).
Oldfield Pine (Del., Va., N. C., S. C., Ga., Ala., Fla., Miss., La., Tex., Ark.).
Torch Pine (Eng. lit.).
Shortleaf Pine (La.).
Rosemary Pine (Va., N. C.).
Slash Pine (Va., N. C.), in part.
Long Schat Pine (Del.).
Long Shucks (Md., Va.).
Black Slash Pine (S. C.).
Frankincense Pine (lit.).
Shortleaf Pine (Va., N. C., S. C.).
Bull Pine (Tex. and Gulf region).
Virginia Pine.
Sap Pine (Va., N. C.).
Meadow Pine (Fla.).
Cornstalk Pine (Va.).
Black Pine (Va.).
Foxtail Pine (Va., Md.).
Indian Pine (Va., N. C.).
Spruce Pine (Va.), in part.
Bastard Pine (Va., N. C.).
Yellow Pine (N. Ala., N. C.).
Swamp Pine (Va., N. C).
Longstraw Pine (Va., N. C.), in part.

THE LOBLOLLY PINE.

By Charles Mohr, Ph. D.

INTRODUCTION.

Among the trees remarkable for the part they take in the spontaneous renewal of the forests in the Southern Atlantic region after the destructive interference by man, the Loblolly Pine is most prominent. This readiness to occupy the ground lends to it a special economic significance in forest growth, aside from its value as a source of timber and as an abundant source of fuel. There can be no doubt that in the future management of the forests of the lower Southern States the Loblolly Pine will be assigned a highly important place. This view is confirmed by the fact that in the older of the States within the limits of its distribution, where the original timber growth has suffered greatest reduction, as in North Carolina, the second growth of this tree is largely depended upon to furnish the timber supply for the existing lumbering industry.

Although known to have contributed to the necessities of the earliest settlers of these coasts, and forming at present a large part of the lumber supplies reaching the markets east and west of the Mississippi River, the merits of the Loblolly Pine and its economic bearings are generally but little understood, wide differences of opinion about its value as a timber tree prevailing. Such diversity of opinion is in itself a sufficient reason for a fuller investigation of its life history.

In the preparation of this monograph the writings of F. A. Michaux[1] and Rev. M. A. Curtis[2] and the report of the Tenth Census[3] have been consulted. To Prof. Lester Ward and Mr. Canby thanks are due for valuable information on the distribution of the Loblolly Pine toward its northern limits. Much information of practical value was elicited by the Division of Forestry from numerous manufacturers of and dealers in lumber in the lower part of Virginia and in North Carolina, which has been largely quoted.

HISTORICAL.

The Loblolly Pine was recognized as a timber tree of value by the earliest settlers of lower Virginia and North Carolina. Its timber was largely used in the construction of their dwellings. Michaux states that three-fourths of the houses in lower Virginia were built of Loblolly Pine, and that its mighty trunks, furnishing shafts of clear timber of largest size, were in early days held in high esteem for masts by the navies of the world. The distinctive characters of the tree were clearly understood by the earliest writers on North American botany. F. A. Michaux defined the northern limits of the tree and its distribution in the southern Atlantic States, and first pointed to its economic value. The Rev. M. A. Curtis gives an account of its distribution in North Carolina and recognized the form distinguished in that State as Slash Pine or Rosemary Pine. Investigations of the forest growth by the writer, under the direction of Prof. Charles S. Sargent, for the Tenth Census, and later investigations made in the transmississippi region, under the direction of the Division of Forestry, have led to a more accurate knowledge of the

[1] Michaux, F. A. The North American Silva. Philadelphia, 1856.

[2] Curtis, M. A. The Timber Trees of North Carolina. Geol. and Natural History Survey of North Carolina, Part III, Botany. Raleigh, 1860.

[3] Volume 9 of the Tenth Census. Charles S. Sargent.

distribution of this tree in the Southwestern States, to the establishment of its western and northern boundary lines, and to a more general appreciation of its economic importance in its eastern and western range.

GEOGRAPHICAL DISTRIBUTION AND ECONOMIC HISTORY.

The Loblolly Pine extends from the Delaware and Maryland peninsula through lower Virginia to Cape Malabar, in Florida, and all over the Gulf States and southern Arkansas to the Colorado River in Texas (see Pl. XVIII). The northern limit of the Loblolly Pine can be described by a line drawn from the lower part of Newcastle County, Del., through the District of Columbia, to Petersburg, Va., thence toward middle North Carolina, following in its western course nearly the thirty-fifth degree of north latitude to the southern boundary of Tennessee, through southern Arkansas to the southeastern confines of the Indian Territory. Its most western station is an isolated tract of small extent near Bastrop, Tex., the sole and last representative of the Atlantic pines in the Southwest.

Michaux the younger established the northern limit of the Loblolly Pine near Fredericksburg, Va., between the Rappahannock and Potomac rivers; M. A. Curtis placed it in or close to the District of Columbia. Its occurrence in the District was, however, considered doubtful, or merely accidental, until in 1888 it was confirmed by Dr. George Vasey, who discovered a group of fullgrown trees in the woods near the Reform School. Mr. William Canby states that he "found in the lower part of Newcastle County, Del, a good many Loblolly Pines, and from the point mentioned it becomes more and more plentiful and widespread in the Delaware-Maryland peninsula."

On the Atlantic Slope, near its northern limit, the Loblolly Pine occurs most frequently in the flat lands of the tidewater districts, forming rarely continuous forests, more frequently less compact bodies of timber, associated with the Shortleaf Pine, oaks, and other hard-wood trees.

In Virginia this tree is not found beyond the northern limit of the Tertiary strata of the coast region, and is not met with west of Petersburg and Richmond.

In the lower part of this State, as in North Carolina, the Loblolly Pine was formerly found in great perfection and abundance—broad forest belts of Loblolly alternating with forests of Shortleaf in Michaux's time. The original forests have, however, in a great measure disappeared, and their progeny, of second or third growth, is now depended upon as the principal source of lumber. On the lands exhausted by the earlier planters, and which have been abandoned for several generations, the timber of this Sap Pine, or Oldfield Pine, has in many localities attained dimensions and a degree of maturity fitting it for all purposes for which timber of the original growth is employed. This important fact is confirmed by parties engaged in the lumber business in southeastern Virginia and in eastern North Carolina.

From information received it is evident that in these parts the second growth of Loblolly Pine is chiefly depended upon for the manufacture of lumber. It is, however, to be presumed that the Shortleaf Pine contributes not a small part of the timber supply. Both of these trees are known by the inhabitants as Shortleaf, or Shortstraw, Pine, and their timber is sawn indiscriminately; the proportions of the lumber of either reaching the markets can therefore not be determined. Mr. Joseph Allard, jr., of Richmond, reports that most of the Virginia Pine is Loblolly Pine, and that every fifty years will produce trees large enough for sawlogs, three to each tree, averaging 16 feet in length. Mr. Sparrow, of Brooke, Stafford County, states that the pine of this county, and in Caroline County, is almost entirely of the Oldfield Pine (Loblolly Pine), and that in the latter from thirty to forty sawmills are cutting this pine. Messrs. J. E. and Edward Rogers, from Suffolk County, each remark that "large quantities of lumber are manufactured from Oldfield Pine, which is fast taking the place of Yellow Pine (*Pinus echinata*), the latter having been used up by the sawmills in this section." The young timber is, according to the same accounts, cut into joists, uprights, and other square stuff for framing; the best quality is selected for flooring, ceiling, and other inside finish, the lumber being sold under the name of Virginia Pine in the markets of Washington, Baltimore, and Philadelphia.

On the coast of southern Virginia the Loblolly Pine forms about 75 per cent of the timber standing. According to all accounts the original growth is rapidly disappearing, but the exceed-

LEGEND.

——— BOUNDARY LINES OF BOTANICAL DISTRIBUTION.

- - - - - - BOUNDARY LINES OF REGIONAL ECONOMIC DISTRIBUTION.

AREAS ON WHICH THE SPECIES OCCURS SCATTERED ALONG WATER-COURSES IN LOWER LONGLEAF PINE BELT.

I — YIELD 1000 FEET B. M. AND LESS PER ACRE. MIXED WITH SHORT-LEAF PINE AND DECIDUOUS GROWTH.

II — YIELD 1000 TO 2000 FEET B. M.

a. IN UPPER LONGLEAF PINE BELT MIXED WITH DECIDUOUS GROWTH.

b. ON HIGHLANDS WITH SHORTLEAF PINE AND DECIDUOUS GROWTH.

III — a. YIELD 3000 TO 4000 FEET B. M. AND OVER PER ACRE. COMPACT FOREST.

b. ORIGINAL GROWTH OF COMPACT FOREST NEARLY EXHAUSTED. SECOND GROWTH PREVAILING.

MAP

SHOWING DISTRIBUTION OF

PINUS TAEDA (LOBLOLLY PINE)

Prepared by CHAS. MOHR,

Agent.

Scale

100 0 100 200 300 400 500 600 Miles

A Hoen & Co Lith Baltimore

ingly large area of exhausted lands abandoned in that section by the cultivators during a long period of time has been taken entire possession of by this tree.

In North Carolina the Loblolly is the predominating tree throughout the eastern coast plain and in the lower part of the State, where it forms extensive forests, more or less frequently interspersed with Longleaf Pine. South of Cape Fear River, however, the latter prevails almost exclusively. In the extensive region watered by numerous streams flowing into Albemarle and Pamlico sounds, in the rich, moist soil of the wide swamps above tide water, the Loblolly reaches its best development, attaining dimensions which place this tree among the timber trees of first order. The primeval forests of this pine have, however, almost completely disappeared in this region, and with them the gigantic trees of this species known by the people as Rosemary Pine, once so highly prized and eagerly sought in shipbuilding. Farther south, in the low pine barrens, this tree is largely superseded by the Longleaf Pine, and is principally confined to the borders of the swamps and to the bottoms along the water courses. Throughout the lower part of the coast pine belt, after the removal of the original timber growth, the progeny of the Loblolly Pine immediately takes possession of every opening, and particularly of the fields thrown out of cultivation.

"The principal kinds of Loblolly recognized by the lumbermen under distinct names are:

"1. Rosemary Pine, the best kind from the trees of best development, of a fine grain but heavy, hard, durable, with but a small proportion of sapwood. At present scarcely known by name at the mills in the section where half a century ago it abounded.

"2. Swamp or Slash Pine, of a coarser grain, with about one-half of the diameter of the tree in sapwood. This kind comprises most of the timber of original growth, and the oldest and best matured second growth.

"3. Oldfield Pine, by the rapidity of its growth, is very coarse-grained and for the greater part sap, scarcely one-fourth of the diameter being heart. At present the principal source of the timber supplies in the coast region."[1]

At the sawmills at Goldsboro, close to the border of the Longleaf Pine region, over 50 per cent of the lumber sawn is Loblolly Pine. On a trip through the forests between the Neuse and Trent rivers it was observed that the Loblolly Pine forms over two-thirds of the tree covering, almost entirely of second growth, of dimensions to furnish sawlogs of from 10 to 18 inches mean diameter by a length of from 15 to 30 feet. The sandy swells and knolls rising above the flats originally covered with the Longleaf Pine are not infrequently occupied by a young growth of Loblolly. The mills at Newbern and vicinity are almost solely depending for their lumber supplies upon these forests of second growth. The same conditions are prevailing in Duplin and in Pender County, by the reports of operators. Mr. C. C. Williams, at Teacheys, in Duplin County, states that 66 per cent of the timber sawn is Loblolly Pine, mostly of second growth, furnishing timber for creosoting and lumber for building purposes.

Mr. Bauman, at Burgaw, reports that the Oldfield Pine (Loblolly of second growth) is coming more and more into use every year, and the demand for this kind of lumber is greatly increasing. In a number of the Newbern journals of 1891 it is stated that over 60,000,000 feet of lumber, board measure, were produced in 1891 by the mills of that place and the vicinity. In the bulletin quoted the output of the nine mills in operation during 1893 is given at 38,000,000 feet, board measure. The timber delivered at the mills sells for about $5 per 1,000 feet, and the price of rough lumber averages $12.

In the latest report on the forests of North Carolina the acreage of the Loblolly Pine, including the land covered with the second growth, and where the Loblolly Pine is taking the place of the Longleaf Pine, is stated as exceeding 4,000,000 acres. The standing merchantable timber can be said to cover 1,150,000 acres. Allowing 4,000 feet, board measure, to the acre, this will make 4,600,000,000 feet of standing Loblolly Pine in 1893. The total cut of Loblolly Pine for the same year has been reported at 290,000,000 feet, board measure.[2]

In South Carolina and Georgia the Loblolly Pine is confined all over the coast pine belt to the more or less swampy borders of the pine barrens scattered among the broad-leaf evergreens and

[1] The Forests, Forest Lands, and Forest Products of Eastern North Carolina. W. W. Ashe, p. 41, Bull. 5, N. C. Geol. Survey.

[2] W. W. Ashe, Bulletin No. 5, North Carolina Geol. Survey, Raleigh, 1894, p. 41.

deciduous trees peculiar to these latitudes—the Magnolia, Sweet and Red Bay, Black Gum, and Titi, associated with the Cuban Pine. The timber of the Loblolly Pine produced in these swamps is of inferior quality, with the sapwood from 4 to 5 inches on a radius of from 8 to 12 inches. It has been noticed that among the original tree-covering Loblolly Pines above 2 feet in diameter were frequently found affected with dry or red rot.

On the dry rolling pine uplands of these States to the foot of the mountain ranges, rising to an elevation of 800 to 1,000 feet above sea level, as well as of the Gulf States east of the Mississippi, this pine is found more or less dispersed among the hard-wood timber, but is considered of no value except for fuel; the trees branch a short distance above the ground and the timber is too knotty to be fit for lumber.

Five trees from the damp, flat pine barrens bordering upon the swamps, felled for test logs in Hampton County, S. C., showed the following dimensions:

Measurements of five trees.

Number of rings on stump.	Diameter at breast high.	Height of tree.	Length of timber.	Diameter below crown.	Sapwood on radius of butt.
	Inches.	*Feet.*	*Feet.*	*Inches.*	*Inches.*
103	26	118	55	17	5¾
103	22	118	70	14	4½
80	17	103	66	13	3½
95	19	112	53	14	.....
63	14	90	54	9	3

In peninsular Florida the Loblolly Pine is more rarely found, its place in the old fields being taken either by Cuban Pine or the Florida Oldfield Pine (*Pinus clausa*).

In the eastern Gulf States throughout the coast pine belt the Loblolly Pine is scattered along the swamps bordering the water courses. Until of late years it has been cut only on special orders for low-priced stuff intended for temporary purposes. As an instance, the fact may be cited that the millions of feet of square sawn timber and of lumber required for the buildings of the New Orleans World's Exposition were mostly Loblolly Pine, sawn at Pearlington, Miss. Since the introduction of the dry-kiln it is extensively used for flooring and inside finish. In the fresh, deep soil of light loam of the coast plain and the valleys in the upper part of the pine belt—the region of mixed growth—this tree is found in great perfection. In these districts it furnishes clear sticks of from 50 to 60 feet and over in length. A considerable proportion of the long and heavy sticks of hewn timber reaching the Mobile market for export as "pitch pine" coming from the upper division of the coast pine belt in Alabama are Loblolly Pine. The timber of the Loblolly Pine from the table-lands of north Alabama is of excellent quality, with but a small proportion of sapwood from 2 to 3 inches on a radius of from 10 to 12 inches, heavy, of a fine close grain and hence of greater durability and strength. The lumber from that region finds a ready market, being used for all the purposes of the house carpenter, and is indiscriminately sold with the product of the Shortleaf Pine.

On the table-lands of the Warrior coal field the Loblolly Pine is better developed than in any other part of this or the adjoining State of Mississippi. If not found in compact forests of any considerable expanse, it forms bodies of heavy timber covering the flat and badly drained tracts, from a few to many acres in extent, associated with the hard wood growth peculiar to a moist soil. It might be said that about one-half of the pine timber growth of these highlands consists of the Loblolly Pine.

The following measurements have been taken of trees felled in Cullman County, Ala., from heavily timbered land several acres in extent:

Measurements of four trees.

Rings on stump.	Diameter breast high.	Height of tree.	Length of timber.
	Inches.	*Feet.*	*Feet.*
78	21	101	41
156	24	103	40
100	22	104	45
137	19	106	57

In Louisiana, west of the Mississippi bottom, the Loblolly Pine is found frequently scattered in the level woods bordering upon the grassy marshes of the coast. North of the region of the Longleaf Pine on the pine flats with a poor, sandy, undrained soil, between Lake Beaudeau and Bayou Dauchitt, extending to the Arkansas State line, this species forms the principal tree covering. The tree is cut only for local consumption in the absence of means of transportation.

In Arkansas heavily timbered forests of Loblolly Pine cover the flat woods in the southeastern part of the State and the region of the Tertiary and Post-Tertiary formation. The lower levels in the rolling uplands are covered with heavily timbered forests of the Loblolly Pine. It forms in this State an important factor in the manufacture of lumber. From observations made in the logging camps in connection with the principal points of production along the St. Louis and Iron Mountain Railroad south of Gurdon and on the St. Louis and Southwestern Railroad it can be safely assumed that about one-half of the lumber cut and shipped as "Yellow Pine" to Northern markets from southwestern Arkansas is Loblolly Pine, the other half being Shortleaf. The flood plain of the Little Missouri River and the Ouachita River is covered with extensive forests of this tree. The deep soil, a stiff sandy loam, flooded after every rainfall, produces a heavy and finely developed timber growth. Upon one acre, representing fairly the average of the merchantable timber standing, 30 trees were counted of from 12 to 48 inches in diameter at breast high; of this number were found: One tree 48 inches in diameter at breast high, length of timber estimated at 40 feet; one tree 36 inches in diameter at breast high, length of timber estimated at 35 feet; three trees 30 inches in diameter at breast high, length of timber estimated at 35 feet; seven trees 23 inches in diameter at breast high, length of timber estimated at 35 feet; three trees 15 inches in diameter at breast high, length of timber estimated at 35 feet; fifteen trees 12 to 15 inches in diameter at breast high, length of timber estimated at 24 feet.

Measurements of four trees.

Rings on stump.	Diameter at breast high.	Height of tree.	Diameter below crown.	Length of timber.
	Inches.	*Feet.*	*Inches.*	*Feet.*
85	17	85	12	47
150	21	105	14	58
83	20	96	12	37
110	22	109	12	68

The timber of these trees was almost free of any defects; sap from 3 to 4 inches on radius.

In Texas this species is distributed in greater or less abundance to the south and southwest of the Shortleaf Pine region over an area exceeding 6,800 square miles. There is even less basis for statistical statements regarding timber standing at present and consumption than for the Shortleaf Pine, since it is not even recognized as a particular species, and always cut together with the latter, especially between the Trinity and the Brazos rivers. No data have lately been obtained of the annual production of lumber derived from the Loblolly Pine forests in this State, but in the light of the statements of the Tenth Census[1] it must contribute largely to the timber supplies of this State. According to this authority, the merchantable timber of Loblolly standing in 1880 was estimated at 20,907,000,000 feet, board measure, and the cut for the same year at 61,500,000 feet, board measure.

PRODUCTS.

VALUE AND USES OF THE WOOD.

Considered solely as the source of furnishing an abundant and cheap material for purposes where strength and durability are not the first considerations, the Loblolly Pine would be entitled to take its place among the timber trees of greater importance. The average tree of full growth, as it is generally found in the original forest on a poorer soil, furnishes timber with a fair proportion of heartwood, with sticks of from 30 to 50 feet and over in length, free from blemish and in some points scarcely inferior to the timber of the Shortleaf and sometimes even of the Longleaf Pine. In fact, the selected lumber of Loblolly classes with the latter in many of the markets for the same

[1] Charles S. Sargent, report of Tenth Census, Vol. IX, p. 541, 1884.

uses by the house carpenter, while the inferior grades are largely consumed for secondary purposes. Of late years the value of the lumber even of lower grades has been much enhanced by the process of kiln-drying, now universally introduced into the mills. After the removal of the water from the sapwood by exposure to a current of heated air, the lumber loses its proneness to get discolored or to "blue" by the rapid development of the mycelium of a fungus and greatly gains in its capability of a good finish, as well as in durability, and is thus rendered suitable for many purposes for which, without such treatment, it would be rejected.

The consumption of Loblolly Pine lumber is constantly on the increase in the markets of the North, as the lumber of the White Pine becomes scarce and more expensive. The sappy timber of second growth is every year coming more in demand, especially in foreign markets, where this cheap timber is rendered durable by creosoting. In the highest state of perfection, which is only attained in the regions most favorable to its development, no other pine was deemed of higher value or was more eagerly sought after for masts and other heavy spars of ships. Before the use of iron in naval construction for these purposes, the Loblolly Pine timber of largest size was eagerly contracted for in all the Southern ports by every one of the maritime powers of Europe. In consequence, the trees which could furnish timber of the dimensions and qualities required for such purposes have become exceedingly scarce, and can be said to have almost entirely disappeared.

The Rev. M. A. Curtis, in his account of the Loblolly Pine,[1] quotes the following statement on the habitat and the dimensions of this tree, from the pen of Mr. E. Ruffin, of Virginia, which, illustrating a feature of the life of the Southern forest forever past, I can not refrain from introducing here:

> This (Slash Pine) tree grows only on low, moist lands, and is the better for timber and grows larger in proportion to the richness of the land. Among other gigantic forest trees on the rich and wet Roanoke swamps, mostly of oak, poplar, gum, etc., the few pines which yet remain tower above all others; I have visited several standing trees and stumps of others which have been cut down and which measured 5 feet in diameter, and were supposed to have been from 150 to 170 feet high.

In evidence of the dimensions of the trees, the writer gives the sizes of the squared sticks cut in Bertie County, made into a raft, and shipped in 1856 by way of the Dismal Swamp Canal to New York. These sticks varied from 50 to 86 feet in length by a mean diameter of from 26 to 31 inches, containing from 347 to 537 cubic feet each. Remarking further:

> All of these sticks are nearly all heartwood; thence it follows that the proportion of heartwood must have been very large, the timber must have been resinous or it would not be good, and it must be durable or it would not serve for masts and other long spars for ships exposed to the alternations of wetting and drying, and for which only the best materials are permitted to be used.

The inferior growth of the Loblolly Pine furnishes vast supplies of cordwood. Immense quantities are shipped from the coast of Virginia and North Carolina to the large cities on the Atlantic seaboard. It is chiefly used where a brisk flame with a quick heat is required, viz, in bakeries, brickkilns, and the kilns of potteries. In its fuel value, the wood of this tree ranks with the better class of resinous trees. Large quantities of the wood are also used for the burning of charcoal.

RESINOUS PRODUCTS.

Regarding the production of resinous products from this pine there has existed a wide divergence of statements. A. F. Michaux states that this tree affords turpentine in abundance, but of a less fluidity than that of the Longleaf Pine, and suggests that as it contains more sapwood a deeper incision would yield a larger product. Rev. M. A. Curtis follows Michaux in this statement, and the writer, relying upon the information from operators in south Alabama, was also led into the error of supposing this tree to yield an abundance of resin for distilling, similar to the free-flowing resin of the Cuban Pine, and published a statement to the effect that this tree was tapped wherever found. A trial box made at the request of the writer seemed to confirm the opinion as to the character of the resin. It appears now, however, that the tree boxed (not inspected by the writer) could not have been a Loblolly, for lately a number of true Loblolly Pines, tapped accidentally in a turpentine orchard, were found in Washington County, Ala., and showed that the resin

[1] M. A. Curtis: Trees and Shrubs of North Carolina, Raleigh, 1860, p. 23.

of this pine does not flow freely and hardens so rapidly on exposure that it can not be profitably worked. An experienced operator at the place confirmed this to be the experience everywhere with this kind of pine. The statements regarding the use of this tree for its resinous product can therefore only be explained by a confusion of names applied to the different pines, and it was most likely the Cuban Pine to which the operators referred.

In a report lately published by the State geologist of North Carolina the remark is made: "It is said that the crude turpentine of the Loblolly Pine has so much water in it that it yields only a poor spirits of turpentine."[1] This, to be sure, is a misconception; but the statement confirms the fact that this species is not tapped for its resin, which had also been observed by the writer a short time previously in the Loblolly Pine forests of North Carolina as well as South Carolina and Georgia.

From an extensive series of analyses of the resin of fresh specimens of both Longleaf and Loblolly Pine collected in Georgia and South Carolina, it appears that the wood of Loblolly contains but little less resin than that of Longleaf; that the distribution of resin in the log is practically the same, and, what seems most remarkable, that the composition of the resin, as far as the relation of spirits of turpentine and rosin is concerned, is nearly the same (being quite variable in both), so that the absence of free "bleeding" or abundant resin exudation can not be due to a lack of liquid oil, but must be caused by other physiological peculiarities.

NOMENCLATURE AND CLASSIFICATION.

The Loblolly and half a dozen other species, mostly Pacific and Mexican,[2] form a natural group of timber trees included in Englemann's *Eutadæ*, which might fitly be designated as the group "torch pines," and can be characterized as embracing trees, mostly of larger size, with more or less resinous, coarse grained wood, long leaves by threes in a fascicle, and with lateral cones provided with thick, woody scales bearing a stout, sharp prickle. The distinctive characters of this species have been early recognized by Pluckenet, one of the earliest writers on American plants[3] and Linnæus described the tree under the name of *Pinus tæda*[4] which was adopted subsequently by all botanists. The name given to this pine by Linnæus in 1753 has never been changed. In 1789 Aitan established a variety, *P. Tæda* var. *tenuifolia* (Hort. Kew., III, 368), which, however, has not received recognition.

BOTANICAL DESCRIPTION AND MORPHOLOGY.

Leaves three in the close, elongated sheath, 6 to 9 inches long, slender, stiff, rigidly pointed, channeled, and strongly keeled on the upper side, of a pale green color; cones nearly sessile, single, in twos or threes, roundish-ovate or ovate-oblong, about 3 inches long, with the scales hard and woody, the pyramidal apophysis with a strong, recurved prickle; seeds small, their wing an inch or over long.

This species is easily distinguished from its most frequent associates—the Longleaf and Shortleaf Pine—by its slightly glaucous foliage at all seasons, and by its more slender and almost smooth terminal buds; from the former and from the latter by the more robust shoots and buds; and from both the species named, and also from the Cuban Pine, by its characteristic cones.

ROOT, STEM, AND BRANCH SYSTEM.

The stout taproot of this pine is assisted by powerful laterals which divide into numerous branches and descend into the soil, usually at a short distance from the trunk; but where a hard, compact subsoil is encountered they are often seen to run for a greater or less distance near the surface. In the localities most favorable to its growth, the massive trunk of the Loblolly Pine is in its dimensions not surpassed by any other pine of the Atlantic forest region. In such cases the tree attains a height of 120 to 150 feet and over, with a diameter of from 4 to 5 feet breast high, and with the trunk clear of limbs for a length of from 60 to 80 feet.

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[1] The Forests, Forest Lands, and Forest Products of Eastern North Carolina, by W. W. Ashe. Bulletin 5 of the Geological Survey of North Carolina, 1895.

[2] Engelmann's revision of the genus Pinus. Transactions of the St. Louis Academy of Sciences, vol. iv, p. 177.

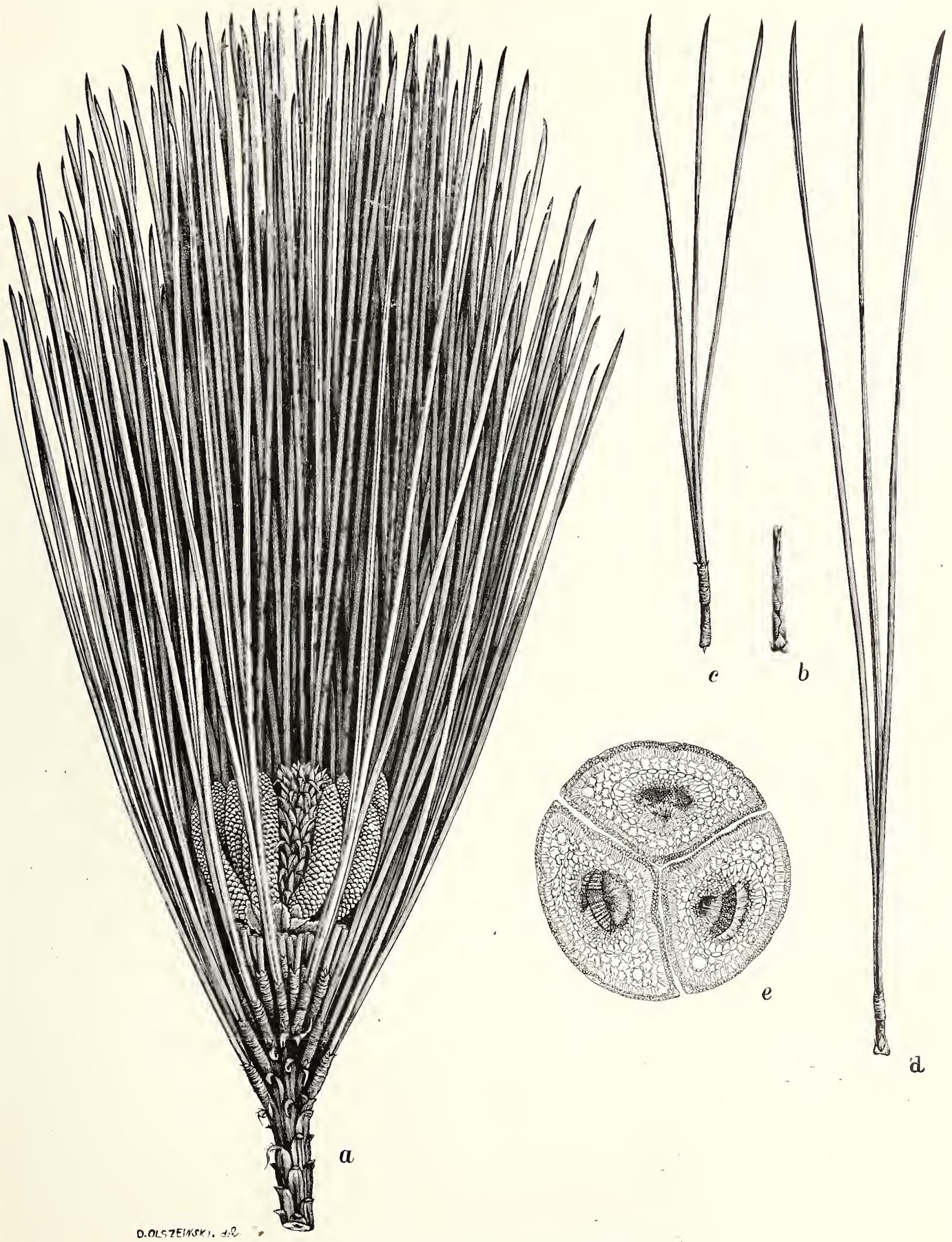
[3] Pluckenet: Amalgestum botanicum. London, 1696.

[4] Linnæus: Species plantarum, 1000, 1753.

EXPLANATION OF PLATE XIX.

[Figures natural size, except when otherwise noted.].

Fig. *a*, branch bearing male inflorescence; *b*, young fascicle of leaves (spring); *c*, *d*, forms of mature leaves; *e*, transverse section of leaf bundle showing structural characters of the leaf (as explained for *Pinus echinata*, *f*, *f*); magnified 20 diameters.



PINUS TÆDA: MALE FLOWERS AND LEAVES.

Such trees, however, have at no time been plentiful and at present are rarely met. In its average growth the diameter of the trunk, breast high, measures from 20 to 24 inches, and the height from 95 to 110 feet. In wet places, somewhat distended at its base, the trunk tapers very gradually to the crown, which covers from one-third to one-half of its height. The lowest limbs are horizontally spreading, and toward the upper part of the tree they become gradually more erect. The largest limbs are rarely found over 20 feet in length. The primary branches dividing in a regular order of ramification into numerous branches and branchlets, the crown becomes full and compact toward the top. The bark of the full-grown tree is, in the lower part of trunk, from 1 to 1½ inches thick, generally rough, of a grayish color, becoming smoother, flaky, and reddish brown as the tree grows older.

LEAVES.

The leaves are united, to the number of three, in a smooth, close sheath, which in the young foliage is about 1 inch long and in the next season scarcely half that length. (Pl. XIX, *c*, *b*, *d*.)

In the bushy growth of less than ten years the leaves are scarcely 5 inches in length, resembling closely the foliage of the Shortleaf Pine of equal age. Prof. L. Ward notes this resemblance as a singular fact, which, as he very pointedly remarks, has the effect of obscuring the gradual appearance of this species among the young growth of the Shortleaf Pine.[1] In the following years the leaves are from 7 to 9 inches long, less densely crowded on the slender branches than in the Longleaf and Cuban Pine, and persisting to the third year; the foliage is of a more open spray. The leaves are stiff, slightly twisted, roughish on the finely serrulated edges and the prominent midrib, channeled on the upper side, abruptly tipped by a rigid, sharp point (Pl. XIX, *c*, *d*), and of a pale green color. They are scarcely one-sixteenth of an inch wide, about half as thick, and present in the cross section on the dorsal side a convex and on the ventral side a strongly triangular outline. Examined under the microscope they show on both surfaces from 10 to 12 rows of rather large breathing pores (stomata), alternating with rows of numerous hypodermal or strengthening cells, in several layers. The cells of the bundle sheath are thin walled; the fibrovascular bundles are, on their ventral side, surrounded by a single row of small strengthening cells. The rather large resinous ducts, from 3 to 5 in number, are peripheral, and placed irregularly mostly about the angles (Pl. XIX, *e*); sometimes smaller ducts are observed close to the bundle sheath.

FLORAL ORGANS.

The staminate flowers are crowded, from 18 to 20 in number, below the apex of the youngest shoot. (Pl. XIX, *a*.) They are from three-fourths to one inch long, of sulphur-yellow color, and surrounded at the base by from 8 to 10 ovate to lanceolate, leathery, involucral scales; the lowest pair is much shorter than the others and strongly keeled; those of the uppermost row are longest, narrow, lanceolate, and reflexed. The anthers are crowned with an erect orbicular crest. After the discharge of the pollen the flowers are gradually shed. The pistillate flowers form an oblong, erect catkin, borne on a short stalk, singly, in pairs, sometimes 3 to 4, below the apex of the shoot (Pl. XX, *a*) of the season, which by the time of blooming has already reached a length of several inches and is covered with the well-advanced leaf buds. Including their stipe, the female aments are about one-half to three-fourths of an inch long, surrounded by from 15 to 20 involucral scales similar to those of the staminate flower. The carpellary scales are ovate, lanceolate, tapering to a sharp, erect, and somewhat reflexed and twisted point. The small bracts subtending the scales are orbicular, scarcely covering their base.

The flowers open, in the coast region of the lower Southern States, about the second week of March (Mobile, Ala., March 15 to 20), and in the interior from four to five weeks later (Cullman, Ala., April 25).

Immediately after pollination the female catkins increase rapidly in size; before ten days have passed the carpellary scales have doubled in size, and their tips become stiffly erect, the bracts having remained stationary in their growth, and the fertile shoots having grown to the length of 8 inches and over. This period passed, the growth of the conelets during the rest of the season proceeds very slowly.

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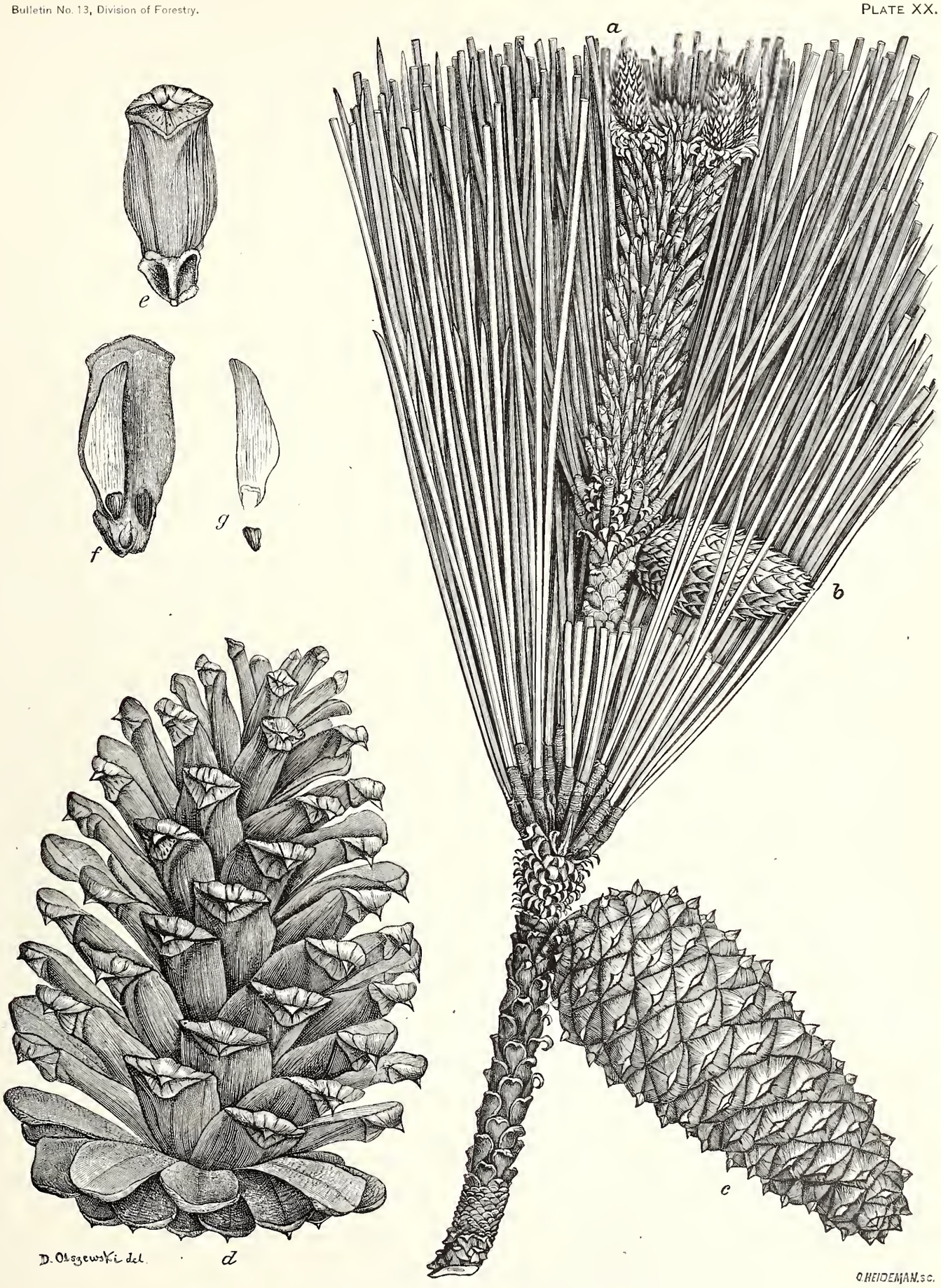
[1] L. Ward: Botanical Gazette, February, 1886.

EXPLANATION OF PLATE XX.

Fig. *a*, branch bearing two subterminal aments of female flowers at end of shoot of the season; *b*, immature cone of one season's growth; *c*, mature closed cone of two seasons' growth; *d*, mature open cone after shedding seed; *e*, cone scale, outer or dorsal side, showing the broad umbonate apophysis end with its sharp transverse ridges and the stout reflexed prickle; *f*, inner or ventral view of the same with the seed in place; *g*, seed and wing detached.



PINUS TÆDA: FEMALE FLOWERS, CONE, AND SEED.

At the beginning of the second season the immature cones are scarcely one-half inch wide and less than an inch long (Pl. XX, *b*), and from that time on increase in size and by the following October have reached their maturity. The ripe cones are lateral, almost sessile, broadly conical or ovate in shape, rarely over 3 inches in length (Pl. XX, *c*, *d*), when fully opened 1½ to 2 inches wide, and of a light wood-brown color. The pyramidal, swelled, exposed ends (apophyses) of the hard, woody scales with a sharp transversal ridge are armed with a stout, straight, or slightly reflexed prickle. (Pl. XX, *e*.) Having reached their maturity, the cones open slowly, the seeds being gradually discharged during the fall and winter seasons. The cones are apt to remain on the tree till the end of another year, and when they finally separate from the branch by the breaking loose of their very short stalk, leave none of their basal scales behind. The seeds are irregularly truncate or rhomboid in outline, inflated, sharp-edged, with two to three more or less distinct ridges, roughish, dark brown to almost black, and surrounded to the base by the narrow border of their delicate wing (Pl. XX, *g*, *f*), which is over an inch long and from one-fourth to one-eighth of an inch wide.

THE WOOD.

Among the pines of the southern Atlantic forests noted for their economic importance the Loblolly is held least in value as a timber tree. This opinion is chiefly founded on the lesser durability of its wood, being more speedily given to decay under the combined influences of dampness and air, and also on the supposition of its being of less strength than the other pine timbers. There is scarcely a timber tree existing that shows wider differences in the quality and value of the timber. This is strikingly demonstrated when the timber of a tree of full average growth, grown on land broken by the plow, is compared with the timber of a tree in its highest perfection taken from the primeval forest. In the former case the wood is crossgrained, sappy, and quick to decay. In the latter it is finer grained, resinous, has less sapwood, and approaches the timber of the Longleaf Pine.

In general, the well-marked, lighter-colored sapwood is quite broad, and usually about 4 inches, frequently 6 inches and more. It is wider in young, thrifty trees, narrower in old and stunted or slow-grown timber; forms about 60 to 70 per cent of the total volume of stems over one hundred years of age, and 80 to 90 per cent of trees sixty to one hundred years old. The formation of heartwood does not begin before the age of twenty-five, the process being retarded as the tree, or better the particular part of the stem, grows older, so that while the innermost sapwood in a log or disk with twenty-six rings is twenty-five years old, the innermost sap ring is thirty-five years old when the log attains the age of forty-five; it is forty-five years old when the log is sixty-five, and about seventy or even more years old when the log reaches the age of one hundred and fifty or two hundred. It follows that the sapwood is formed of fewer rings in young trees and in the upper part of older stems, but owing to the greater rapidity of growth in these parts the width of the sapwood does not always follow this same law. Since neither width of the ring, nor that of the denser summerwood, the thickness of the cell walls, nor any other important structural feature is changed when the wood of any ring changes from sap to heart wood, the prevalent notions of sapwood being necessarily either coarse or fine grained, light, and weak, are erroneous. The sapwood of a young, well-grown tree is coarse-grained, heavy, and strong; that of an old tree is fine-grained, light, and weak. Since durability on exposure is not to be expected of the sapwood of any pine, the prejudices against the sapwood, and therefore all young timber of this particular kind, are unwarranted. With proper treatment, it will serve all purposes for which any pine wood of its grain and weight can be employed.

Owing to the great amount of water soaked sapwood the weight of green Loblolly timber is very great, varying chiefly between 50 and 55 pounds to the cubic foot, with the sapwood commonly approaching 60 pounds to the cubic foot. Kiln-dried, the wood of the entire trunk of trees one hundred to one hundred and fifty years old weighs about 33 pounds per cubic foot. In such trees the wood of the log 50 feet from the ground is about 20 per cent lighter (and weaker) than that of the butt log, and the wood next to the bark in the butt log is 15 to 20 per cent lighter than the wood of the inner fifty to sixty rings.

In strength the wood of the Loblolly varies chiefly with weight (the same degree of seasoning always presumed), and keeping this in mind, compares favorably with that of any other conifer.

For well-seasoned wood, the following figures represent the average of hundreds of tests on specimens specially collected for this purpose:

	Lbs. per sq. inch.
Modulus of elasticity	1,950,000
Transverse strength	10,100
Compression endwise	6,500
Shearing with the fiber	690

Since the average weight of the test pieces was 40 pounds per cubic foot, being heavier than the average weight of the wood, these figures must be taken about one-sixth lower than given above to represent the true average for the wood of the species.

Like the wood of most conifers, that of Loblolly dries easily and rapidly. In doing so the green lumber loses a large amount of water, dependent chiefly on the proportion of sapwood. Though quite variable, the water in fresh sapwood commonly forms 50 to 60 per cent of the weight, while in heartwood it little exceeds 25 per cent.

The shrinkage consequent on drying amounts to 11 to 12 per cent of the volume; is greater in the lumber of the butt than in that from the top logs, varying in this respect from 13 per cent at the butt to about 10 per cent in the top, a difference which appears due to the difference in the weight of the wood of the different sections. As in other pine, about two-thirds or seven-eights per cent of this shrinkage falls to the tangent (i. e., is along the rings) and about 4 to 5 per cent to the radius.

In kiln-drying, the wood may be taken fresh from the saw and behaves extremely well, suffering no great injury, a fact which has greatly enhanced its value by facilitating its exploitation.

For the details of wood structure, consult the comparative study by Mr. Roth appended to these monographs.

PROGRESS OF DEVELOPMENT.

The crops of seed are produced quite abundantly every year and copiously dispersed over the vicinity of the mother trees by the wind, the offspring quickly taking possession of old fields and clearings in the forest.

The seeds germinate in the early spring. The ends of the cotyledons remain for a short time after germination inclosed in the endosperm. The number of the germinal leaves (cotyledons) is mostly six, rarely seven. At the time of the unfolding of the cotyledons the lower (hypocotyledonary) part of the axis of the plant is about 1 inch in length. The rootlets are half that length, and are provided with several acropetal secondary rootlets. The caulicle grows rapidly, and is soon covered with the stiff, needle-shaped, and strongly serrulated primary leaves. Before the spring season has passed the bundles of secondary or foliage leaves make their appearance in the axils of the former. At the close of the summer season the plantlet has attained a height of from 6 to 8 inches, the upper part of the stem covered with foliage leaves, the acerose primary leaves of the lower part having completely withered. In examining a large number of young plants never less than three leaves in a bundle have been found during this or any subsequent stage of the growth. With the second year the primary leaves have all become reduced to the ordinary form of the leaf bract—lanceolate, acuminate, with fimbriate white hyaline edges and tips.

In all the specimens examined it was found that the growth of the main axis proceeded less rapidly during the second session, but produced a regular whorl of from three to four lateral axes. At the close of the second year the main stem rarely exceeds 10 inches in height.

At the end of their third year the plants are from 18 to 20 inches high, the stem being from one-fourth to five-sixteenths of an inch in thickness. The branches, forming regular whorls, are erect and produce in their turn whorls of secondary order. The root system shows a corresponding increase, the taproot being from 6 to 8 inches long, with numerous stout lateral roots.

RATE OF GROWTH.

With the fourth year the Loblolly Pine enters seemingly upon the period of quickest growth. As ascertained by many measurements, the trees at the end of their fourth year average 3 feet in height and from one-half to seven-eighths of an inch in diameter, and at the end of the fifth year measure nearly 5 feet and from 1 to 1¼ inches in diameter. At the beginning of the seventh year

the tree attains a height of 10 feet, and with the close of the first decade trees are found 12 to 16 feet high and from $2\frac{3}{4}$ to 3 inches in diameter. Some trees begin to mature their first cones by the tenth year.

The above measurements were made in 1890 in the vicinity of Cullman, Ala., on trees taken indiscriminately from the midst and near the border of a dense pine thicket covering a field plowed for the last time in 1882, and from an adjoining opening in the forest protected from fire and but rarely used for pasture.

According to a number of measurements made of trees in the southern Atlantic States, the Gulf region, and southern Arkansas, the Loblolly Pine reaches at the tenth year, on the average, a height of 20 feet, doubling this height during the succeeding decade. During this period of quickest growth the increase in height proceeds at the rate of 2 feet per annum, and trees twenty years old average $4\frac{1}{2}$ inches in diameter breast high. At the age of fifty years the trees are from 65 to 75 feet in height (average about 70 feet) and 15 inches in diameter breast high. The annual increase for this period of thirty years is about 1 foot in height and 0.35 inch in diameter. From numerous observations it appears that the Loblolly Pine attains the fullness of its growth at the age of one hundred years, with a height, on the average, of 110 feet and a diameter breast high of 2 feet, the length of merchantable timber varying between 50 and 60 feet. The annual rate of height growth during the second half century is about eight-tenths of a foot, and the diameter growth eighteen one-hundredths of an inch. Henceforth the growth in height remains almost stationary. A dozen trees from one hundred to one hundred and fifty years old were found to vary from 99 to 125 feet in height, with a length of trunk free from limbs of from 60 to 68 feet and from 19 to 27 inches in diameter at breast height.

From the annexed tabulated records of growth it becomes evident that under similar conditions of soil and exposure the rate of increase for the various stages of growth show but slight differences in localities widely distant from each other.

TABLE I.—*Growth from five to fifty years.*

No. of tree.	No. of rings.	Diameter (breast high).	Height to first limb.	Total height.	Locality.	Remarks.
		Inches.	*Feet.*	*Feet.*		
1	5	1		$5\frac{6}{12}$	Cullman, Ala	Clearing made for pasture in 1879; dense pine thicket.
2	5	1		4	do	Do.
3	6	2		10	do	Do.
4	6	$1\frac{1}{2}$		7	do	Do.
5	6	$1\frac{1}{2}$		$8\frac{3}{12}$	Whistler, Ala	Edge of swampy hummock.
6	7	$2\frac{3}{4}$		10	Cullman, Ala	Clearing, dense pine thicket.
7	7	$3\frac{1}{8}$		12	do	Do.
8	9	$2\frac{1}{2}$		$13\frac{6}{12}$	do	Do.
9	9	$2\frac{1}{4}$		$12\frac{6}{12}$	do	Do.
10	10	$2\frac{3}{4}$		18	do	Do.
224	11	2	8	23	do	Do.
12	12	$3\frac{3}{8}$		20	do	Do.
13	12	$3\frac{1}{4}$	$7\frac{3}{12}$	24	do	Do.
223	12	$2\frac{1}{2}$	10	21	Whistler, Ala	Edge of hummock.
189	13	2	13	19	Gurdon, Ark	Open forest; exposure free.
271	13	$2\frac{1}{2}$	13	20	Eastman, Ga	Do.
222	14	3	10	25	Whistler, Ala	Edge of hummock; slightly oppressed; partially covered.
148	14	$2\frac{1}{4}$	8	21	Eastman, Ga	Opening in forest; under cover; fresh soil.
272	14	2	7	21	Gurdon, Ark	Opening in forest; exposure free; damp soil.
221	15	4	12	35	Whistler, Ala	On gentle decline; opening in forest; soil fresh.
222	16	6	13	30	do	Do.
219	17	6	16	39	do	Natural opening near swamp; soil damp.
220	18	6	17	43	do	Do.
221	20	4	28	33	do	Oppressed.
270	21	4	22	45	Eastman, Ga	Natural opening in forest; under cover.
146	26	$4\frac{1}{2}$	28	33	Gurdon, Ark	Natural opening in forest; exposure free.
269	22	$4\frac{1}{2}$	32	43	Eastman, Ga	Natural opening in forest; suppressed.
267	22	8	25	55	do	Old field; fresh, deep loam; free.
268	24	6	17	39	do	Old field; oppressed.
187	24	$4\frac{1}{4}$	30	47	Gurdon, Ark	In open forest; exposure free.
144	32	6	38	55	do	Open forest; exposure free.
145	32	6	36	56	do	Do.
266	35	12	51	77	Eastman, Ga	Old field; deep, rich loam; fresh, young forest trees of similar size.
143	48	16	30	66	Gurdon, Ark	Open forest; soil damp.
14	44	15	33	68	Stockton, Ala	Flat near banks of Tensas River; open forest; exposure free; March 16, 1888, just past flowering.

TABLE II.—*Growth of Loblolly Pine (Pinus taeda) from fifty to one hundred and fifty-six years.*

No. of tree.	Rings in stump.	Diameter.			Height to first limb (length of timber).	Total height.	Locality.	Habitat, and other remarks.
		Breast high.	Across stump.	Below crown.				
		Inches.	*Inches.*	*Inches.*	*Feet.*	*Feet.*		
300	63	14	13¼	9½	54	90	Ridgeland, S. C.	Low pine barrens, edge of hummock, soil damp, exposure free.
265	70	16	16½	9½	57	86	Eastman, Ga.	Old field, abandoned one hundred years ago; typical for oldest second growth.
261	73	22	.....	.....	50	94	.....do	Close to edge of swamp; open forest; soil wet; exposure free; sapwood 4½ inches.
302	74	12	10¾	6¼	35	80	Ridgeland, S. C.	Close to edge of swamp; somewhat suppressed.
24	80	21	18½	.....	41	101	Cullman, Ala.	Swampy swale; open forest; exposure free.
299	80	18	16½	9⅛	66	103	Ridgeland, S. C.	Swampy hummock; exposure partially free.
141	83	20	20	15½	37	96	Gurdon, Ark.	Low, wet, piny woods; exposure partially free.
139	85	17	15½	12	47	88	.....do	Low, wet, piny woods; exposure free.
217	87	21	.....	.....	40	105	Whistler, Ala.	Low, open forest; soil damp; exposure free.
20	90	22	.....	.....	46	104	Cullman, Ala.	Wet swale; sandy loam; open forest; free.
300	95	19	19½	12	53	112	Ridgeland, S. C.	Edge of swamp; slightly oppressed; sapwood 5 inches.
297	100	27	26½	18¾	56	118	.....do	Low, pine barrens; soil damp; near swamp; exposure free; sapwood 5½ inches.
216	101	23	24	18	51	111	Whistler, Ala.	Open forest, on slight decline; soil drained; fresh; exposure free; sapwood 4½ inches.
142	110	22	22	12	68	109	Gurdon, Ark.	Low, rather dense forest; wet; exposure free.
262	117	22	21½	.....	69	116	Eastman, Ga.	Edge of swamp; soil damp; partially suppressed.
215	118	19	18¼	.....	53	125	Whistler, Ala.	Slight declivity; soil well drained; suppressed.
263	120	22	22½	.....	68	99	Eastman, Ga.	Near border of swamp; soil damp; exposure free.
214	128	23	22½	.....	59	109	Whistler, Ala.	Open forest; soil fresh; exposure free.
27	137	19	.....	.....	57	115	Cullman, Ala.	Open forest; damp swale; exposure free.
213	142	27	286	.....	54	103	.....do	Edge of swamp, damp to wet; exposure almost free.
140	150	21	23	15¾	58	108	Gurdon, Ark.	Flat, wet, rather dense forest; exposure free; slightly oppressed on the sides.
25	156	24	25½	.....	39	103	Cullman, Ala.	Wet swale; sandy loam; exposure free.

From Table III and the corresponding diagram, based upon a considerable number of trees, it appears that the Loblolly Pine is nearly 40 feet high when twenty years old; that the length of the merchantable timber (60 feet) is attained at the age of forty; that this shaft has a basal diameter of 20 inches at the age of one hundred years, and that the age of thrifty growth is practically at an end when the tree is one hundred and ten years old. Comparing this table with those for Longleaf and Shortleaf pines, the excellence of the Loblolly becomes apparent.

TABLE III.—*Rate of growth of Loblolly Pine.*

Age.	Diameter with bark (breast high).	Length of log with upper diameter of 5 inches.	Total height of tree.	Volume.		Periodical accretion or growth per decade.					Average annual accretion.	Current accretion.
				Tree.	Log up to 5 inches diameter.	Decade.	Diameter.	Height.	Area of cross section.	Volume.		
Yrs.	*Inches.*	*Feet.*	*Feet.*	*Cu. ft.*	*Cu. ft.*		*Inches.*	*Feet.*	*Sq. feet.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
10	3.4	.....	18	0.60	.....	First	2.4	18	0.03	0.60	0.06	0.06
20	5.6	.....	37	3.05	.....	Second	2.3	19	.08	2.45	.14	.24
30	7.8	23	50	8.72	7.49	Third.....	2.2	13	.14	5.67	.29	.57
40	10.0	35	61	16.63	15.45	Fourth	2.0	11	.17	7.91	.41	.79
50	11.8	44	70	25.30	24.12	Fifth	1.8	9	.19	8.67	.57	.87
60	13.3	52	78	35.65	34.47	Sixth	1.6	8	.19	10.35	.59	1.03
70	15.5	60	85	49.02	47.88	Seventh	1.5	7	.21	13.37	.70	1.33
80	17.1	68	90	62.44	61.44	Eighth	1.4	5	.21	13.42	.78	1.34
90	18.7	76	95	78.02	77.16	Ninth.....	1.1	5	.19	15.58	.87	1.56
100	19.5	80	98	89.41	88.59	Tenth	.9	3	.16	11.39	.89	1.14
110	20.2	83	100	96.00	95.23	Eleventh	.8	2	.13	6.59	.87	.66
120	20.7	85	102	102.00	101.23	Twelfth	.5	2	.10	6.00	.85	.60

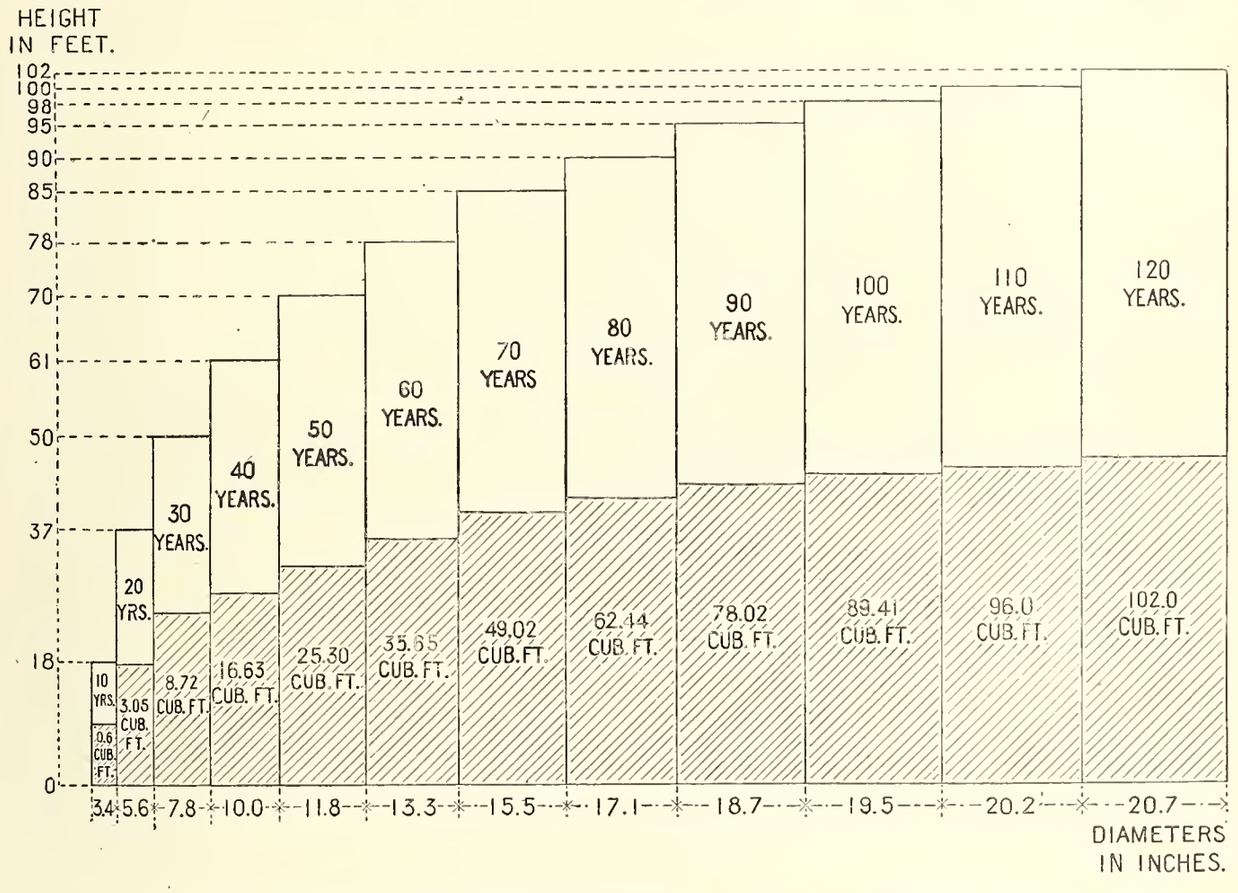


FIG. 12.—Growth of Loblolly Pine: Height, diameter, and cubic contents of average trees at 10, 20, etc., years of age.

CONDITIONS OF DEVELOPMENT.

SOIL AND CLIMATE.

The Loblolly Pine prefers a moist, cool, sandy or light loamy soil, which, if not always moist, should have a greater retentiveness for moisture than is required by most of the other upland pines. It reaches its greatest perfection in the perpetually moist or fresh forest lands, with a soil of a sandy loam, rich in vegetable mold—the accumulation of ages—which border the swamps of the coast region. The tree is not found on the porous, highly siliceous soils of the more elevated uplands, where the Longleaf Pine almost exclusively prevails; it also avoids heavy clay and calcareous soils of the uplands and the alluvial lands.

The Loblolly Pine is a tree of austral regions confined to the humid belt of the Austro-riparian or Louisiana zone and the lower border of the Carolinian life zone, which, on the Atlantic Coast,

follows quite closely the isothermal line of 56° F.; westward, in the direction of the Gulf Coast, the isothermal line of 60°. The mean temperature of the winter along the northern limit is about 45°, with the lowest temperature only occasionally falling below 10° F. This tree approaches the Appalachian zone only under the influence of a peninsular clime between the Delaware and Chesapeake bays.

The Loblolly appears to be indifferent to the wide differences in the amount of atmospheric precipitation existing within the vast range of its distribution. Extending from Florida (isotherm, 74°) to the 39° of north latitude on the Atlantic Coast (isotherm, 56°), it is found of equal thrift on the Gulf shore, with its damp air and annual rainfall exceeding 64 inches, and in the flat woods of Texas, where the mean annual precipitation is only one-half that amount, with a mean of 6 inches during the winter months. In fact, the Loblolly Pine is found most frequently and is more widely distributed in the districts of lesser precipitation. It is certainly more dependent on the supplies of soil moisture than upon atmospheric humidity.

RELATION TO LIGHT AND ASSOCIATED SPECIES.

This species is less exacting in its demands for direct sunlight than the kindred species within its range. To this relation may be ascribed the success which it achieves in the struggle for the possession of the soil with the Shortleaf Pine. Observing this contest as it is going on between the competing species in the forest, the conditions of the soil being equally favorable, the Loblolly Pine, under the cover of shade, outstrips the Shortleaf Pine under the same conditions; and, on the other hand, where the sunlight has had unhindered access, it gives way to its competitor, being then subjected to the disadvantage resulting from a speedier desiccation of the soil. Through such influences it is that, under conditions seemingly equally favorable to either one of these pines, now the one and now the other is found to predominate.

In the deep forests covering the rich swampy lands of the coast regions, the Loblolly Pine forms comparatively a small part of the rich and varied growth consisting chiefly of deciduous trees, Black Gum, Sweet or Red Gum, Water Oak, and Mockernut, to which in the lower South the Magnolia, Sweet Bay, Red Bay, and Cuban Pine are to be added. Although requiring less sunlight than most pines, in the gloomy impenetrable shade of these dense forests the progeny of the Loblolly Pine has no future, especially as these lands once cleared are devoted to tillage, being of great agricultural value.

On the lands of a poorer, more exposed soil in the maritime plain of the southern Atlantic States, in Virginia and North Carolina, and in southwestern Texas, this pine forms more or less compact forests. In these forests the tree is always succeeded by its own progeny, either in the course of nature or after the artificial removal of the original forest growth. On the coast of Georgia, in Florida, and in the coast plain of the eastern Gulf States, the Loblolly Pine is scattered among the Cuban and the Longleaf Pine: there its second growth meets a formidable competitor in the first named of these species. In the flat woods, deprived of drainage, the Cuban Pine is always found to vastly outnumber the Loblolly among the young forest growth. In the upper part of the great maritime pine belt the Loblolly Pine is frequently found among the mixed growth of Magnolia, Spanish, Red, Post, and Blackjack oaks, Mockernut and Pignut Hickory, Shortleaf Pine, and Southern Spruce Pine. Throughout this region the tree takes almost undisputed possession of the old fields.

In the interior, on the uplands of oaks and Shortleaf Pine, the Loblolly is sure to gain the upper hand and to retain its hold among the young forest growth, giving way to its most aggressive competitor, the Shortleaf Pine, only when under the disadvantage of a greater exposure and a greater lack of moisture in the soil.

ENEMIES.

Principally confined to low, damp localities, not easily liable to invasion by the frequent conflagrations which scour the Southern pine forests, the Loblolly Pine suffers less from destruction by fire than any other species. In virtue of the inherent facilities for its natural renewal resulting from its fecundity and from the rapidity of its development from the earliest stages of growth, any damages inflicted by that agency are more easily repaired. The same causes afford it also

greater protection against incursions of live stock. As also observed in the Shortleaf Pine, the rapidly growing seedlings form, after a few years, thickets of such density as to be avoided by the larger quadrupeds, and by the time such thickets, in the course of natural thinning out have become more open, the trees have reached dimensions which place them beyond the danger of being tramped down or otherwise injured by live stock. The rapid spread and thrift of the second growth, unprotected and uneared for, observed everywhere within the range of the distribution of this pine, are witnesses to its greater immunity from such dangers.

Owing to the large amount of sapwood, the timber of the Loblolly is more liable to the attacks of fungi and to the ravages of insects. The mycelium (spawn) of large polyporous fungi is found frequently infesting the woody tissue of the living tree, the hyphæ (filaments) of the spawn destroying the walls of the wood cells, causing the wood to assume a reddish color and rendering it brittle in the same way as is observed in the living Longleaf Pine timber affected with the disease called "red heart." It seems that the destruction caused by this disease in the Loblolly Pine is from the start more rapid in consequence of the larger proportions of sapwood, and perhaps also on account of the broader bands of soft springwood naturally accompanying wood of rapid growth.

In a piece of wood examined in north Alabama, the filaments of the spawn of one of these fungi crossing each other in every direction were found to form a dense film interposed between the spring and summer wood, causing its easy separation in the direction of the concentric rings, and, as the destruction of the wood proceeds, forming finally a compact layer of the nature of amadou, or tinder. In the longitudinal section the rays were found full of cavities, caused by the breaking down of the cell walls, and these cavities were filled with the white film of these filaments, which similarly affected the adjoining tracheids of the resinous summerwood.

The felled timber left on the ground is soon infested by a host of fungi of the genera *Agaricus*, *Tramites*, *Lentinus*, *Polyporus*, and others, the nearer identification of which has not been undertaken.

From the very limited observations that have been made it clearly appears that this pine suffers equally as much, if not more than the other pines of Southern growth from insect enemies of various kinds. The larvæ of the same capricorn beetles (*Cerambicidæ*) burrow in the body of the timber. Those of the round-headed borers (*Caleophora*) dig their channels in the sapwood, as is indicated by the occurrence of several species of jumping beetles (*Buprestidæ*) which are found clinging to the leaves and branches of this tree. The most fatal injury it sustains is caused by the bark borers (*Tomicidæ*); this pest particularly affecting the trees during the formation of the last cambium layer in the later summer months. Trees felled in August are immediately infested by multitudes of these destroyers. Favored by a high temperature and an abundance of nourishment, several generations of them succeed each other before the close of the season, the countless broods soon infesting every tree in the vicinity and carrying their work of destruction over the full expanse of the young forest growth. Under this affliction the forests often present, by their drooping rusty-colored foliage, a sad picture of disease and decay. Weevils (*Curculionidæa*) deposit their eggs in the youngest tender shoots; the larvæ which hatch from them eat their way into these shoots, causing their decay, and thus destroy the symmetry of the tree and impair the usefulness of the resulting timber. Other species of the same family puncture the older branches, lay their eggs in the exuded resin, their larvæ injuring the tree in a similar way. The larvæ of spittle insects injure the terminal buds, which are also found infested by the larvæ of Pitch-moths (*Retiniæ*), causing them to wither. The foliage seems to be less frequently attacked by sawflies (*Lophyrus*) than the tender young leaves of the Longleaf Pine, as by the rapidity of their growth the young leaves sooner harden, and are therefore less relished by these depredators. The evidences of the work of the pine-leaf miners (caterpillar of *Gelechia*) have been freequently observed in Alabama, and everywhere are seen the deformities caused by gall flies and scale insects.

NATURAL REPRODUCTION.

If the Shortleaf Pine has been spoken of emphatically as the future timber tree of the light rolling uplands of the interior, the Loblolly Pine might be fitly designated as the timber tree of greatest promise in a large part of the coast plain from the middle Atlantic States to the limits of compact forest growth beyond the Mississippi River. The promptness with which it colonizes the

old fields and other clearings, and the tenacity with which it retains from one generation to another the ground once taken possession of, clearly point to the important part this tree is to take when the ruthless stripping of timber lands practiced at present gives place to the management of the forests under a system of fostering care, tending to their future maintenance and to the disposal of their resources on the principle of true economy with an eye to the future welfare of the country. No timber tree will be found better adapted for forest planting in the southern part of the Atlantic forest division. It is only in the narrow belt of flat woods along the shores of Florida, Georgia, and the eastern Gulf region that it is likely to find its superior in the Cuban Pine (*Pinus heterophylla*).

Besides the advantages of adaptability to varied soil and climate, it excels in rapidity of growth during the earliest stages, and the copious production of seeds, which, almost without fail, are plentifully distributed every year over the vicinity of the parent trees. As an evidence of the facility with which the reproduction of a compact forest by this pine is effected, it is only necessary to point out the spontaneous groves near the settlements, representing, as they do, every stage of development.

In the coast region the second growth, if not interfered with under proper soil conditions, yields in fifty to sixty years timber of dimensions rendering it fit to be sawn into lumber well adapted for various uses, as already mentioned.

CONCLUSION.

In this attempt at a sketch of the life history of this tree, the object was constantly kept in view of placing its value among the products of the Southern forests in the proper light. From the consideration of the structure of the wood and its physical properties it clearly appears that although inferior to the wood of the Longleaf and Cuban pines, the timber of this species fully equals that of Shortleaf Pine, and that the present practice of treating them as equivalent seems therefore justified.

As an abundant and cheap source of timber of inferior grades, and especially when the rapidity of its growth is considered, the Loblolly Pine is of no less economic importance than the other timber trees of the same section. At present held in low esteem in the great lumbering districts of the lower South, where the supplies of the superior timber of the Longleaf Pine still abound and receive the preference, the value of the timber of the Loblolly Pine is quickly recognized in other districts which, but a short while ago boasting of similar resources, are now stripped of them. Its physiological peculiarities make it an important factor in the future forestry of this section. Its propagation is successful over a vast expanse in the southern section of the Atlantic forest region, and by its productive capacities, mode of development, and behavior toward competing species in the struggle for existence, the Loblolly Pine possesses great advantages for its natural and artificial renewal, adapting it particularly for the restoration of the forests on the lowlands of the maritime region.

THE SPRUCE PINE.

(PINUS GLABRA Walt.)

HISTORICAL.
DISTRIBUTION.
ECONOMIC IMPORTANCE.
BOTANICAL DESCRIPTION.
PROGRESS AND DEVELOPMENT.
ENEMIES.
REQUIREMENTS OF DEVELOPMENT.

THE SPRUCE PINE.

(*Pinus glabra* Walt.)

Synonyms: *Pinus glabra* Walter, Fl. Caroliniana, 237 (1788).
Pixis mitis β (?) *paupera* Wood, Cl. Book, ed. 41, 660 (1855).

COMMON OR LOCAL NAMES.

Spruce Pine (S. C., Ala., Fla.).
Cedar Pine (Miss.).
White Pine (Fla.).
Walter's Pine (S. C.).
Lowland Spruce Pine (Fla.).
Poor Pine (Fla.).

THE SPRUCE PINE.

By Charles Mohr, Ph. D.

INTRODUCTORY.

The Spruce Pine is the least common of the pines found in the lower Southern States. The tree is frequently confounded by the inhabitants with the Shortleaf Pine, to which it is closely related. Its vernacular names are, in different sections of its range, applied to several other pines; in Florida to the Sand Pine (*Pinus clausa*), in north Alabama to the Scrub Pine (*Pinus virginiana*), and in the southern part of this State even to the Cuban Pine. Although never forming extensive bodies of timber, being for the most part widely scattered among the broadleaf evergreens and deciduous trees with which it is associated, and in the quality of its wood of low rank, this little known tree has been given a place here among the monographs of the timber pines of the South Atlantic forest region in order to dispel for the future its confusion with some of these trees, and at the same time to attract the attention of the tree planter to it as the only one of its kind which thrives and propagates in the shade, keeping its ground closely surrounded by the luxuriant and varied tree growth with which it is associated, and soon outstripping the same by the rapidity of its growth. Considering that among all others of its kind in the same region it attains the fullness of its growth in the shortest time, with dimensions which render it valuable for many of the purposes for which the softer and lighter kinds of timber are used, its economic importance can not be ignored.

HISTORICAL.

The Spruce Pine was first recognized as a distinct species and described as *Pinus glabra* by Walter, in his Flora Carolinensis in 1788, having since that time been known under this name by the botanists. Hidden in the remote semiswampy dense forests, it escaped the attention of later botanists. Neither the Michauxs, father and son, nor Nuttall were aware of its existence. It was unknown for fully three-fourths of a century until rediscovered by Professor Ravenel in the swamps of Berkeley County, S. C. Ten years later the tree was described in Chapman's Flora, 1860. It was recognized by Professor Hilgard in the Pearl River Valley, Mississippi. In 1880 its distribution was traced by the writer through the Gulf region to its western limit in the eastern parishes of Louisiana.

DISTRIBUTION.

The Spruce Pine is a tree of the southeastern Atlantic forest, confined to the subtropical region or the Louisianian zone of American botanists, within that part of the coastal plain of the southern Atlantic and the Gulf States embraced between the thirty-first and thirty-third degrees of north latitude; from South Carolina through middle and northwestern Florida to Louisiana, with its western limit between the Pearl and Mississippi rivers. This tree is mostly found single or in groups on the low terraces with a fresh or damp soil rich in humus, rising above the swamps subject to frequent overflow. It is seldom seen to form compact bodies of timber; such have only been observed between the Chattahoochee and Choctawhatchee rivers, in northwestern Florida, where, to all appearances, this tree finds its best development on isolated tracts of fertile red loam lands.

ECONOMIC IMPORTANCE.

Nowhere forming pure forests of any extent, this pine is of little importance to the lumbering interests of the present, and its timber has never become an article of commerce. Although the timber is of inferior quality, it furnishes lumber of dimensions equaling the best of our timber

pines. It is light, soft, easily worked, and capable of good finish, and is without doubt fit for many uses of the house carpenter and cabinetmaker in the manufacture of furniture and other purposes. Owing to the large percentage of ash and smaller quantity of resinous matter, the actual fuel value of the wood of the Spruce Pine is lower than that of the other Southern pines: for its resinous product the tree is considered of no value, since the resin does not run when it is tapped.[1]

In its wood the Spruce Pine resembles Loblolly. The sapwood is wide, and even in trees seventy-five to eighty years old it forms more than three-fourths of all the wood. The change from sap to heart wood begins as early as in the pines mentioned, and as in these is retarded with age and also with any suppression of growth, so that in stunted young trees the change begins later, and the sapwood of these, as well as old trees, is always composed of a greater number of rings. While green, the wood is very heavy, weighing 45 to 50 pounds per cubic foot, varying in this respect chiefly with the proportion of sapwood. When kiln-dried, the wood weighs about 27 pounds to the cubic foot; it is heavier at the butt, weighing about 31 pounds to the cubic foot, and lightest near the top, where its weight falls as low as 25 pounds to the cubic foot. As in other pines, the heaviest wood is produced by young trees. The amount of water contained in the fresh wood is quite variable—very great in the sapwood, and consequently in young timber—but falls little below 50 per cent of the weight of green timber on the whole. Its behavior in drying is the same as in light grades of Loblolly; it dries rapidly and without much injury, shrinking, during this process, by about 10 per cent of its volume.

The strength of this wood is, as in other conifers, closely related to its weight. Accordingly, the Spruce Pine is inferior to both Shortleaf and Loblolly.

From careful experiment it appears that its—

	Lbs. per sq. inch.
Modulus of elasticity is about	900,000
Transverse strength	6,000
Compression endwise	4,000

In its structure the wood resembles too closely that of the Loblolly to enable as yet any identification on this feature, and the description for the wood of the Loblolly answers perfectly for the product of this species. As in Loblolly and other hard pines, summerwood and springwood are always well defined, the summerwood forming from 15 up to 40 per cent of the total volume, differing in this respect from the White Pine which it has been claimed to resemble. Thus while decidedly softer on the whole than Loblolly it is by no means to be expected that the Spruce Pine can hope to serve as a general substitute for the true White Pine.

BOTANICAL DESCRIPTION.

Leaves invariably in pairs, with short and close sheath; soft, slender, 1½ to 3 inches long, twisted; cones short-stalked, horizontal or reflexed, the cone scales with a flat apophysis, the depressed umbo unarmed or with a minute weak erect prickle.

The Spruce Pine is readily distinguished by the close bark of its trunk which in the crown and the limbs is perfectly smooth and of a light gray color; in foliage and in cones it resembles most closely the Sand Pine (*Pinus clausa*) of the coast region of Florida and the eastern Gulf States, which however is distinguished by the more prominent apophysis of the cone scales, armed with a short, stout, reflexed prickle. The Shortleaf Pine, to which it is next related, is distinguished by the same characters and further by the fascicles of two and three leaves and the rigid young shoots of the season covered with slender, long, loosely fimbriated bud scales.

The leaves are concave, faintly serrulate, short pointed, and are shed during the latter part of the second season or the beginning of the third.

In the details of their structure they differ little from the leaves of the Shortleaf Pine; the rows of breathing pores (stomata) are numerous on both surfaces; the strengthening cells of the cortical tissue are smaller and less numerous; the resin ducts, two or three, are parenchymatous, the cells of the bundle sheath thin walled. The two fibro-vascular bundles distant and without strengthening cells.

[1] Ravenel: Proceed. of Elliott Society, Charleston, I, 52.

The male flowers are lateral, sessile, and about one-half to three-fourths of an inch long, slender, surrounded by five to six pairs of short ovate, rather obtuse stiff scales, with a narrow, membranaceous lacerated border. The crest of the anther is elliptical, with fine denticulations. The small female aments are mostly single, short stalked, the carpellary scales lance-shaped with slender tips and subtended by the short infertile bract.

The cones are mostly single with a short stalk and of various shapes on the same tree, from round to oblong ovate or more or less cone-shaped, from $1\frac{1}{4}$ to 2 inches long, and, on the opening of the scales from three-fourths to one inch wide, of a light tawny color. The scales are softer and more flexible than in the Shortleaf Pine, the apophysis broader, with the umbo depressed, unarmed, or with a minute, weak, erect, and deciduous prickle, the ridge faint, hazel-brown on the inside. The somewhat triangular roughish seeds, black with brown speeks, about three-sixteenths of an inch long and one-eighth inch wide, separating easily from the wing which is little over one-half inch long and surrounds the seed to the base.

PROGRESS OF DEVELOPMENT.

The Spruce Pine begins to flower and to produce perfect seeds at an age of twelve to fifteen years, in greatest abundance between twenty and forty years; the flowers appear during the earliest part of March; shortly after pollination the female aments assume a horizontal position, and finally become more or less reflected. At the end of the first season the conelets are of the size of a large pea. The cones mature in the second year in the month of September; the seeds are freely shed early in the fall. They germinate during the fall and early in the coming spring; the plantlets, with eight to ten slender, soft cotyledons, are over an inch long. The terminal bud develops rapidly, densely covered with the slender, soft primary leaves which are sharp pointed and frequently over an inch in length. Early in April seedlings are found over one-half foot long, later in the season fascicles of the foliage leaves appear in the axils of the upper primary leaves, when the lower wither and disappear near the end of the season. At this stage the seedlings are generally a foot high with the root system less developed than in its kindred species at the same age; the taproot scarcely 2 inches in length with a few short lateral roots.

With the twentieth year the trees are generally from 30 to 35 feet high and 4 to $4\frac{1}{2}$ inches in diameter, the stem clear of limbs for the length of about 12 feet. They attain their full growth at an age of from sixty to seventy-five years.

The trees for the United States timber tests from the border of the swamps on the banks of the Tensaw River in Baldwin County, Ala., showed the following dimensions and age:

Measurements of five trees.

No. of tree.	Rings on stump.	Diameter breast high.	Length of timber.	Height of tree.	Sap on radius.
		Inches.	*Feet.*	*Feet.*	
458	78	22	45	120	$5\frac{1}{2}$
459	53	17	56	96	$5\frac{1}{2}$
----------	46	15	40	85	All sap.
460	75	22	57	99	5
461	83	23	60	116	5

From these figures it appears that the two trees forty-six and fifty-three (average forty-nine) years old have an average volume of 63 cubic feet and grew at the rate of about 1.3 cubic feet, while the three trees seventy-five to eighty-three (average seventy-eight) years old have an average volume of about 152 cubic feet and an average yearly growth of about 2 cubic feet. The following represents a typical case:

Growth of Spruce Pine.

Rings on stump. *a*	Height of tree.	Diameter without bark.	Volume of wood.	Average yearly growth in—		
				Height.	Diameter.	Volume.
	Feet.	*Inches.*	*Cubic ft.*	*Feet.*	*Inches.*	*Cubic ft.*
10	37	5	2.5	3.7	0.5	0.2
20	51	8.5	9.5	1.4	.3	.7
30	67	12	26	1.6	.3	1.6
45	84	15	51	1.1	.2	1.6

a For age of tree add about three years.

The Spruce Pine attains a height of from 85 to 110 feet and over; the trunk is clear of limbs for a length of from 45 to 60 feet, and it is from 2 to 2½ feet in diameter breast high, seldom exceeding 3 feet. The largest trees observed were about 120 feet in height by a girth of fully 10 feet breast high.

The taproot appears to be less strongly developed than in the Shortleaf, the lower lateral roots run for a short distance close to the surface before penetrating the ground; the bark is close, with deep, narrow furrows, separating in narrow thin scales and of a reddish-brown color. The limbs are horizontal, dividing in rectangular spreading branches and branchlets. The leaves also become in the latter part of the season widely spreading, the density of the foliage being reenforced by the leaves of the short branchlets produced on the older branches from adventitious buds. To this spreading habit of the ultimate division of the branches and of the leaves is due the peculiar spray of the foliage, similar to that of the true cedars.

ENEMIES.

No observations have been made of the injuries inflicted upon this tree by insects. Trees, after having passed the period of full growth, at the age of about 100 years are very frequently affected with decay in the stump and with redheart in the top. In the damp hummock lands the tree is rarely touched by fire. Where the underbrush and the vegetable matter of the soil covering has been destroyed by repeated conflagrations, however, the trees begin to sicken and soon die.

REQUIREMENTS OF DEVELOPMENT.

The Spruce Pine requires the warm climate of the subtropical zone, with a mean annual temperature of about 66° F. and a mean temperature of 49° F. in the winter months (in central Alabama the thermometer falls sometimes to an extreme of 5° F.), and the humid atmosphere of the coastal plain, with a mean annual rainfall of 54 inches, evenly distributed throughout the year. This tree will endure, during the early stages of its growth, more shade than any other of the pines of the Atlantic forest region, perhaps the White Pine (*Pinus strobus*) excepted. Retarded in its growth under severe oppression, it will finally force its way through its close surroundings, and having gained a freer access to light, it pushes its crown rapidly above the broad-leaved evergreens and deciduous trees which luxuriate on the same ground. It demands a loose soil, rich in humus, fresh to moist but not wet, with a deep porous subsoil, which in these lands is frequently a light, sandy loam.

The Spruce Pine is never found in the forest of the alluvial bottoms with their heavy soil, subject to frequent overflow, nor in the dry, sandy pine forests. Where it finds the soil conditions most favorable to its growth, Magnolias, Cucumber trees, Sweet Gum, Mockernut Hickory, and Beech are found of greatest thrift, not infrequently associated with the Shortleaf and the Loblolly pines. The undergrowth on such lands is luxuriant, consisting of Dogwood, Holly, Summer Haw, and a variety of shrubs, Bush Huckleberries (*Vaccinium virgatum*), Farkleberries (*V. arboreum*), Storax Bushes (*Styrax grandifolium*), Cornals (*Cornus sericea*), and Blue Palmetto, forming dense brush interlaced by numerous woody climbers (*Vitis*, *Ampelopsis*, *Wistaria*).

As has been observed in northwestern Florida, where it finds the proper soil conditions, the second growth of this pine soon occupies the clearings made in the original forest. Tracts of young forests of much promise have been met with between the Choctawhatchee and Chattahoochee rivers. The hummock land, forming the home of the Spruce Pine, being with the increase of the population rapidly claimed for cultivation, this beautiful pine will soon be solely confined to the most remote and inaccessible localities. Being the only really soft pine of the Southern States, and having by its shade endurance a peculiar forest value, this tree will probably form an important part in the future, when forestry has become an established business.

NOTES ON THE STRUCTURE OF THE WOOD OF THE FIVE SOUTHERN PINES.

(*Pinus palustris, tæda, echinata, heterophylla, glabra.*)

Sap and Heartwood.
Annual Rings.
Spring and Summer Wood.
Grain of the Wood.
Minute Anatomy.

NOTES ON THE STRUCTURE OF THE WOOD OF THE FIVE SOUTHERN PINES.

(Pinus palustris, heterophylla, echinata, taeda, glabra.)

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The wood of these pines is so much alike in appearance and even in minute structure that it can be discussed largely without distinction of species. The distinctions, as far as there are any, have been pointed out in the introduction. Here it is proposed to give in more detail the characteristics of the wood structure.

SAP AND HEART WOOD.

All five species have a distinct sap and heartwood, the sap being light yellow to whitish, the heart yellowish to reddish or orange brown. The line of demarcation between the two is well defined, without any visible transition stage. The location of this line does not as a rule coincide with the line of any annual ring, so that the wood of the same year's growth may be sap on one side of the tree and heart on the other. The difference in this condition may amount to ten or twenty rings, which on one side of the same section will be heart, on the other side sap.

There is considerable variation in the relative width of the two zones as well as the number of rings involved in either and also in the age at which the transition from sap to heartwood begins. This age was rarely found to be below twenty years; as a rule the transformation begins in young trees when the particular section of the tree is between twenty and twenty-five years old, but the progress of heart formation does not keep pace with the annual growth, being more and more retarded as the tree grows older, so that while in a section twenty-five years old twenty-two rings may be sapwood, at thirty-five years the sapwood will comprise only thirty rings; at forty-five years, forty rings; at eighty years, fifty rings; and in sections two hundred years old the outer eighty to one hundred rings will still be sap. A young tree of Longleaf Pine (No. 22) was, for instance, found to show the following relations:

Section.	Height from stump.	Age of section.	Rings of sap.
	Feet.	*Years.*	*Number.*
III.....	6	46	40
IV.....	14	38	33
VII.....	22	30	27
IX.....	30	24	23
XII.....	42	18	17

The change from sap to heart wood begins earlier in young trees than in the younger portions of older trees; in these latter, sections thirty-six and forty years old are quite commonly found still entirely made up of sapwood, while in young trees, as stated above, the change begins before the age of thirty years.

The progress of the transformation is somewhat influenced by the rate of growth; it is slower in slow-growing trees and usually also on the slower-growing radius, i. e., there are more rings of

sapwood. The width of the sapwood, on the other hand, stands in relation to the rate of growth in an opposite manner; it is wider in young and thrifty than in old and stunted trees, and widest along the greatest radius of any section; similarly, it is wider in the faster-growing Loblolly, Cuban, and Spruce pines than in the slow-growing Longleaf.

Besides being of a lighter color the sapwood differs from the heartwood in several respects. Its resin is limpid and oozes out of the pores or resin ducts of any fresh cut; that of the heartwood does not flow, except in rare cases, from saturated pieces or "light wood." The sapwood contains much less rosin—both rosin and turpentine—than the heart wood. Thus in a section of Longleaf the sapwood contained only 0.2 per cent of turpentine and 1 per cent of rosin, while the heart contained from 2 to 4 per cent of turpentine and 12 to 24 per cent of rosin, and though this is an extreme case the heart generally has three to five times as much resinous matter as the sap. The fresh sapwood contains three to five times as much free water as the heartwood and is, even when seasoned, more hygroscopic and subject to relatively greater shrinkage than the heart. This capacity for taking up water readily is probably one of the reasons why sapwood decays more readily. In addition, the parenchyma cells of the medullary rays and resin ducts (see further on) contain, at least in the outer parts of the sapwood, living protoplasm and reserve food materials which are readily seized upon by fungi which cause "bluing" and decay. Such living tissue does not exist in the heartwood. The heartwood in old logs generally is heavier than the sapwood. This is not due to any later thickening or growth of its cell walls, after their original formation, but is due chiefly to two causes:

1. The heartwood of old logs was formed when the tree was younger, and made, naturally, heavier wood.

2. The accumulation of resin in the heart already referred to increases often very considerably the weight of the heartwood.

In the same way the sapwood of old logs, such as supply the sawmills, is weaker than the heartwood of the same logs, but this is not because the wood is in the sapwood condition, but because it is lighter and its summerwood per cent smaller, being, as stated before, the product of old age when heavy and strong wood is no longer formed. Chemically the wood substance of sapwood is practically like that of heartwood; the coloring substances which permeate the cell walls in heartwood appear to be infiltrations, i. e., deposited in the walls from solutions; they are insignificant in amount, and their true nature, especially the processes leading to their formation, are not yet fully understood. The most modern views which consider these coloring bodies or heartwood substances as products of oxidation of tannin still require confirmation.

ANNUAL RINGS.

The layers of growth, known and appearing on any cross section as annual rings, show very distinctly in the wood of these pines. In a section 8 or 10 feet from the ground the rings are widest at the center, of considerable width for the first thirty to fifty rings, the period of most rapid growth in height: then they grow more and more narrow toward the periphery. In the last sixty to one hundred rings of very old logs the decrease is very small, the rings remaining practically of the same width. The same year's growth is usually wider in the upper part of the stem, both in young and old trees, but the average width of the rings is naturally greater in the upper part only of young trees; in old and also in stunted trees it is smaller, since in these the upper portions do not share in the more rapid growth of the early years.

Rings over half an inch wide are frequently seen in Loblolly and occur in Spruce Pine; rings one-fourth of an inch in width occur in very thrifty saplings of all five species, but the average width of the rings for sapling timber is usually less than one-fourth of an inch, commonly one-eighth. In trees over one hundred years old it drops to one-twelfth of an inch and even below. The average width of the rings is normally smallest in Longleaf Pine, being one-twenty-fifth of an inch and less. (See also tables and diagrams of rate of growth in the introduction, as well as in the several monographs.)

The influence of orientation on the width of the rings is completely obscured by other, more potent influences, so that sometimes the radius on the north side, other times that of some other

side, is the greatest; and it is a common observation to see this relation vary within wide limits, even in the trunk of the same tree.

Stunted trees of Longleaf Pine over one hundred years old with an average width of ring of one-fiftieth of an inch are frequently met with in old timber; of the other species no such trees were observed. The decrease of the width of the rings from center to periphery is never perfectly uniform. Not only do consecutive rings differ within considerable limits, but frequently zones of narrower rings, including thirty or more years' growth, disturb the general regularity. Where these zones consist of very narrow rings, one-fiftieth of an inch or less, the wood is of distinctly lighter color and weight. Since the value of this class of wood depends not only on its strength and stiffness but also on the fineness of its rings (grain), in so far as the grain influences both the appearance and the ease of shaping as well as other mechanical properties, the width of the annual ring is of great importance, from a technical point of view, the finer-ringed (grained) wood of the same weight always deserving and mostly receiving preference.

The rings of the limbs are narrower than the corresponding rings of the stem. Moreover, they are usually of different widths on the upper and lower side of the same branch, those of the latter excelling in width those of the former. Frequently the wider lower part of a ring of a branch appears like a "lune" on the cross section, quite wide (one-eighth of an inch and more) in its lower median part, and scarcely visible, often entirely fading out, on the upper side. This difference is commonly accentuated by the appearance of the wood itself. In the upper part the wood of the ring is normal and light colored, owing to a very small summerwood per cent; on the lower wide part, the "lune," the wood is commonly of reddish color, either even throughout the entire width of the ring, or else in several varicolored bands, which give the appearance of two or more separate ill-defined rings. Sometimes the earliest formed springwood is included in this unusual coloration, at other times only the median portion of the ring. This "red wood," as it has been termed by the French and German writers, is composed of very thick walled cells and increases markedly the weight of the wood, so that the wood of the side containing it is usually much the heaviest. It is of interest that the several "lunes" in any cross section occur rarely, if ever, exactly one above the other, but commonly the radius passing through the middle of one "lune" makes an angle of 20 to 40 degrees with the radius passing through the middle of another "lune." Often successive "lunes" show considerable deviation in position and commonly differ in width or degree of development. Accepting the most recent explanation of this phenomenon as expressed by Hartig and Cieslar,[1] it would appear that the formation of these broad "lunes" of especially strong cells is due to pressure-stimulus on the growing cambium, caused by the weight of the limb and its peculiar position, increased at all times by movements of the limb due to the wind. Moreover it seems that the formation of one well-developed "lune" relieves for a time the pressure, and with it the necessity for a repetition of this formation. These "lunes" are most conspicuous in the limbs of these pines near the trunk, and disappear at variable distances from the trunk and with them disappears the eccentricity and the difference in appearance and weight of the wood of the limbs. Immediately at the junction of limb and stem the pressure is constant, and the result is the formation of almost uniformly thick-walled tissue in all parts of the ring, giving to the "knot" its great weight and hardness.

Lunes similar to those of the limb are frequently observed in the stems of small trees; wherever this has been noted it was found on the underside of a leaning or curved portion.[2] Occasionally such a "lune" extends for 12 and more feet up and down.

Quite distinct from this modification of the annual ring is another modification frequently seen, especially in young trees, giving rise to so-called "false" rings. It consists in the appearance of one or more, rarely two, dark-colored lines, which precede the true summerwood band of the ring. These lines, resembling the summerwood in color and composed like it of thick-walled cells, follow the true springwood of the year and are separated from the summerwood and from each other (if there are more than one), by a light-colored line resembling springwood. While occasionally this is somewhat misleading in counting the rings, a moderate magnification usually suffices to

[1] A. Cieslar, "Rotholz d. Fichte," Centralblatt f. d. g. Forstwesen 1896, p. 149, and Robert Hartig "Das Rothholz der Fichte" in Forstlich-naturwissenschaftliche Zeitschrift, 1896, p. 165.

[2] Cieslar produced them at will by bending young spruce saplings.

distinguish the real character of the tissues, as described later on. A more serious difficulty arises in very old, slowly growing trees, where the ring sometimes is represented by only one to three cells (see fig. 18) and occasionally disappears, i. e., is entirely wanting in some parts of the cross section. Generally these cases, due to various causes, are too rare to seriously interfere in the establishment of the age of a tree.

SPRING AND SUMMER WOOD.

The difference between spring and summer wood is strongly marked in these pines, the transition from the former to the latter being normally abrupt and giving to the annual ring the appearance of two sharply defined bands. (See figs. 13 and 18 B.) In wide rings the transition is sometimes gradual. The springwood is light colored, has a specific gravity of about 0.40, and thus weighs somewhat less than half as much as the darker summerwood, with a specific gravity of about 0.90 to 1.05, so that the weight and with it the strength of the wood is greater, the larger the amount of summerwood. (See diagram, fig. 14.)

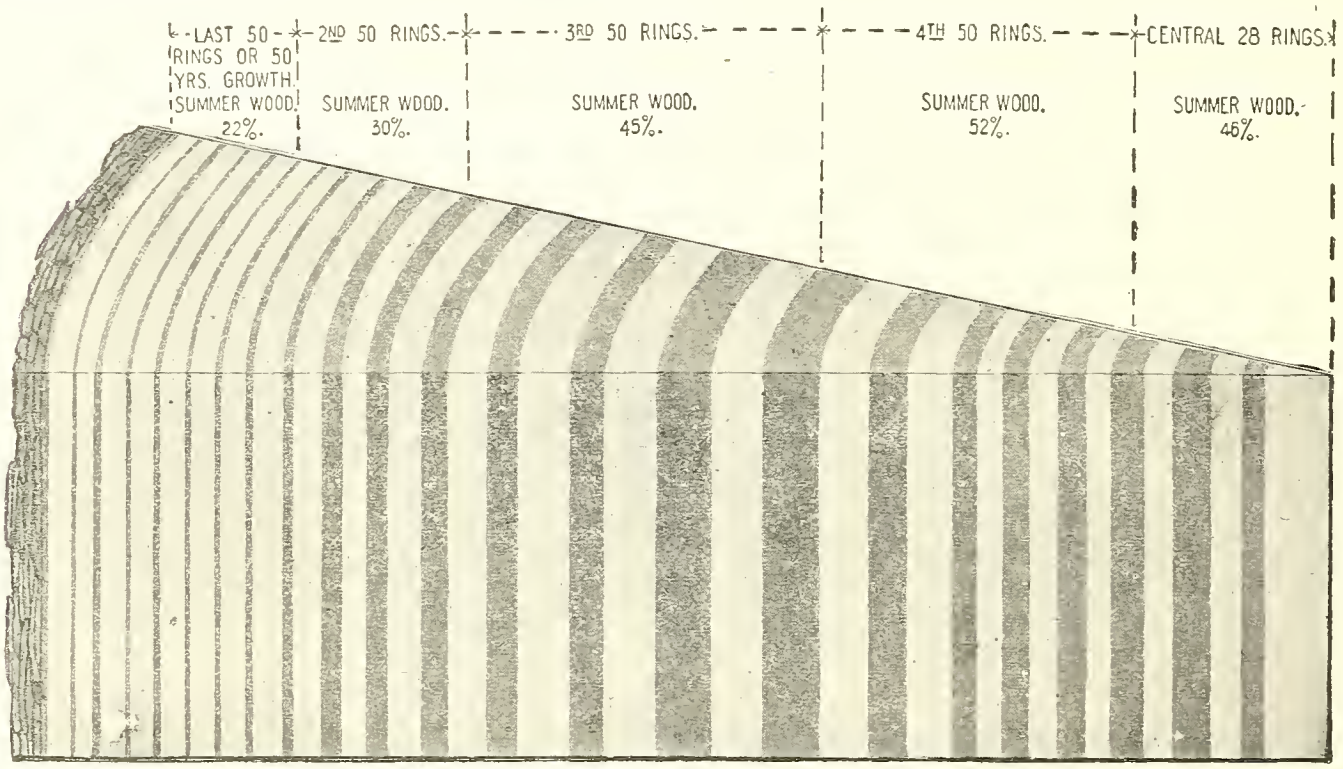


FIG. 13.—Variation of summerwood per cent from pith to bark.

The absolute width of the summerwood varies generally with the width of the ring (see diagram, fig. 15), i. e., the wider the ring the wider the summerwood band. It decreases in a cross section of an old log from near the pith to the periphery, and in the same layer, from the stump to the top of the tree. Where the growth of the stem is very eccentric, the wood along the greater radius has the greatest proportion of summerwood; thus, in a disk of Longleaf, for instance, there is on the north side a radius of 152 mm. with 27 per cent summerwood; on the south side a radius of 98 mm. and a summerwood per cent of only 20 per cent. In the stump section the great irregularity in the contour of the rings is accompanied by a corresponding irregularity in the outline of the summerwood.

The summerwood generally forms less than half of the total volume of the whole log (see fig. 13); it forms a greater part of the coarse-grained wood which was grown while the tree was young than in the fine-ringed outer parts of the log, grown in the old age period. It also forms a greater part in the volume of the butt than of the top log, and thus fully explains the well-known difference in the weight, strength, and value of the various parts of the tree. The following table serves to illustrate this point. The numbers in each line refer to the average values for the same ten annual layers through three sections of the tree at varying height. The figures in *italics* below refer to specific gravity for the same layer. The values for specific gravity were calculated on the basis of

allowing a specific gravity of 0.40 for springwood and 0.90 for summerwood, the values for the entire disks as actually observed being given below:

Summerwood per cent and specific gravity in various parts of a tree of Longleaf Pine.

Rings from periphery.	1 to 10	11 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	71 to 80	81 to 90	91 to 100	101 to 110	111 to 120	121 to 130	131 to 140	141 to 150	151 to 160	161 to 170	171 to 180	181 to 190	191 to 200	201 to 210	211 to 220	221 to 230	231 to 236	Average for total.
Section I, 3 feet from ground.	39	44	40	42	38	35	45	32	44	66	43	43	52	56	48	46	48	43	47	47	52	45	42	*a*15	45
	.59	*.62*	*.60*	*.61*	*.59*	*.57*	*.62*	*.56*	*.62*	*.73*	*.61*	*.61*	*.66*	*.68*	*.64*	*.63*	*.64*	*.61*	*.63*	*.63*	*.66*	*.62*	*.61*	*.47*	*.625*
Section IV, 35 feet from ground	26	24	25	34	28	24	26	24	35	49	31	33	43	34	40	31	34	33	33	31	22	*b* 6	....	....	29
	.53	*.52*	*.52*	*.57*	*.54*	*.52*	*.53*	*.52*	*.57*	*.64*	*.55*	*.56*	*.61*	*.57*	*.60*	*.55*	*.57*	*.56*	*.56*	*.55*	*.51*	*.43*	....	....	*.545*
Section VII, 70 feet from ground	23	16	17	18	18	20	16	20	18	26	21	24	19	19	22	16	18	*c* 2	....	....	....	....	....	....	18
	.51	*.48*	*.48*	*.49*	*.49*	*.50*	*.48*	*.50*	*.49*	*.53*	*.50*	*.52*	*.49*	*.49*	*.51*	*.48*	*.49*	*.41*	....	....	....	....	....	....	*.490*

a Six rings next to pith. *b* Two rings. *c* One ring.

The observed values of specific gravity for the three sections are 0.700, 0.560, and 0.490, respectively.

It will be noticed that the greatest difference between the calculated and the actual value of specific gravity occurs in the section at the stump. This is fully accounted for by the fact that large amounts of resin, not considered in the values of summerwood per cent, always occur in this portion, adding from 5 to 20 per cent to the weight of the wood.

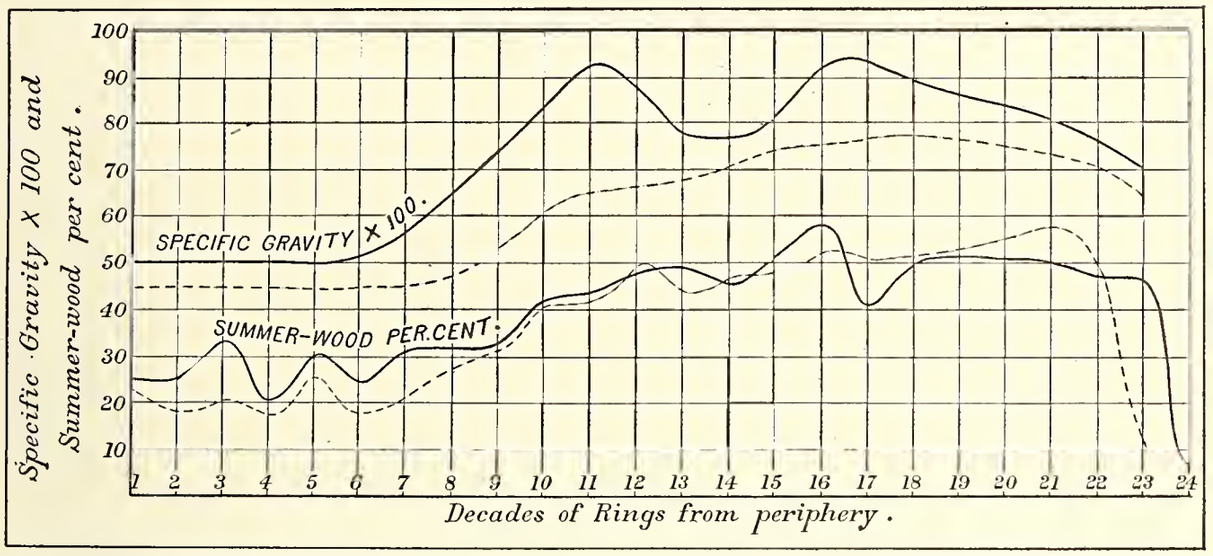


FIG. 14.—Variation of specific gravity with summerwood per cent and age of section in Longleaf Pine, the solid lines referring to a section 3 feet from the ground, the dotted lines to one 14 feet from the ground. (Specific gravity as actually observed on pieces of 1 inch radial extent.)

In stunted trees the summerwood forms nearly as great a per cent of the total volume for the whole tree as in thrifty trees of the same age, but in the stunted growth, or extremely narrow ringed portion of otherwise normal trees, the per cent of summerwood is markedly decreased, a feature which becomes conspicuous in the lighter color of the wood of such portions. (See diagram, fig. 15.) Where, on the other hand, the rate of growth in an old tree is suddenly increased by the accessibility of more light, for instance, the summerwood per cent also is disproportionately increased, but this disproportion appears to be more transient, i. e., a decrease in the summerwood per cent sets in sooner than for the rate of growth or the width of the rings. (See fig. 15.) In some of the rapidly grown Loblolly and Spruce Pine the summerwood forms but a small part of the first ten to twenty years' growth, and in all cases the first few rings about the pith have but little summerwood. In general, the summerwood per cent varies in the several species as well as in the individual with the weight of the wood, which is least in the Spruce Pine, greatest in Cuban and Longleaf Pine, and stands between these in Loblolly and Shortleaf. It furnishes a very useful criterion to distinguish between these groups and especially to select strong timber.

In the limb the summerwood is most abundant in the knot (all wood practically partaking of the character of summerwood, at least as far as the thickness of cell walls is concerned) and in the part next to the stem, decreasing with the distance from the trunk. As might be expected, it also forms a larger per cent of the wood of the underside of limbs and the concave portions of bent trunks.

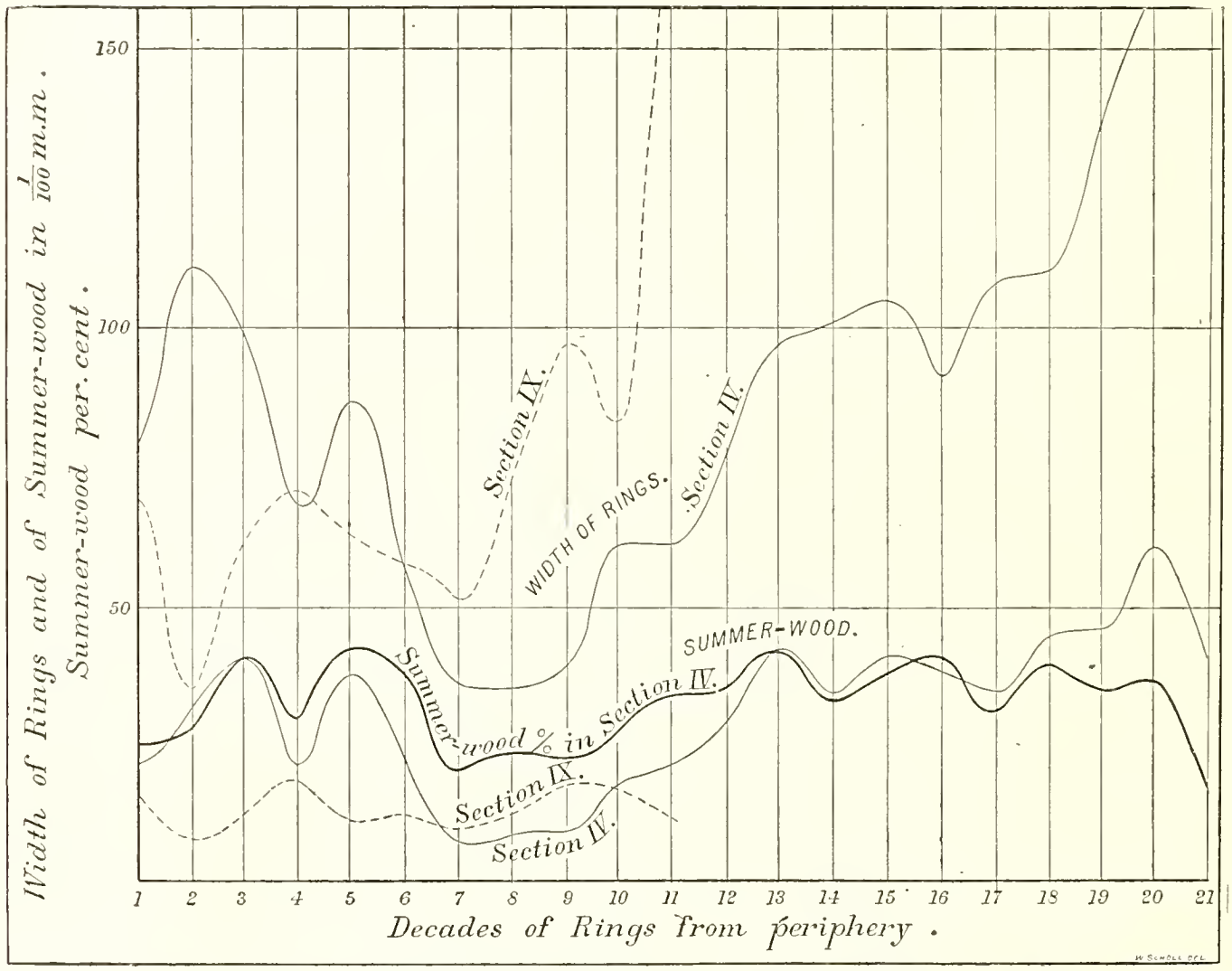


FIG. 15.—Variation of summerwood per cent with rate of growth (width of ring), in tree No. 3, Longleaf Pine.

NOTE.—Only the heavy line represents summerwood per cent; the others indicate the actual width of the rings (upper pair) and of the band of summerwood (lower pair).

GRAIN OF THE WOOD.

Though usually quite straight grained, the wood of these species is by no means always so. Spiral growth leading to "cross-grained" lumber occurs frequently, is usually more pronounced in the basal portions of the tree, and commonly varies from pith to bark in the same log. Wavy grain resembling that of the maple (curly maple) has not been observed, but an irregular wavy grain, due to the fact that the surface of the trunk for many years is covered with small, low eminences, 1 to a few inches across, is frequently seen, especially in Longleaf Pine, and leads to remarkably pretty patterns. Unfortunately the contrast of spring and summer wood being so very pronounced, the figures are somewhat obtrusive and, therefore, not fully appreciated.

MINUTE ANATOMY.

The minute structure or histology of the wood of the five species under consideration is that of a group whose position in a general classification of the wood of pines is indicated in the following scheme, suggested by Dr. J. Schroeder, and more completely by Dr. H. Mayr,[1] in which they appear as part of group 2 of Section I.

[1] Dr. J. Schroeder, Holz der Coniferen, Dresden, 1872, p. 65; Dr. H. Mayr, Waldungen von Nordamerika, München, 1890, p. 426.

Section I. Walls of the tracheids of the pith ray with dentate projections.

a. One to two large, simple pits to each tracheid on the radial walls of the cells of the pith ray.—Group 1. Represented in this country by *P. resinosa*.

b. Three to six simple pits to each tracheid on the walls of the cells of the pith ray.—Group 2. *P. taeda, palustris*, etc., including most of our "hard" and "yellow" pines.

Section II. Walls of tracheids of pith ray smooth, without dentate projections.

a. One or two large pits to each tracheid on the radial walls of each cell of the pith ray.—Group 3. *P. strobus, lambertiana*, and other true white pines.

b. Three to six small pits on the radial walls of each cell of the pith ray.—Group 4. *P. parryana*, and other nut pines, including also *P. balfouriana*.

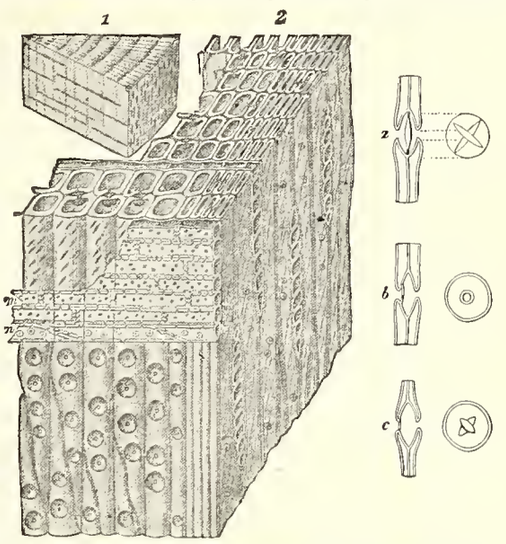


FIG. 16.—Schematic representation of coniferous wood structure: wood of spruce—1, natural size; 2, small part of one ring magnified 100 times. The vertical tubes are wood fibers, in this case all "tracheids," *m*, medullary or pith ray; *n*, transverse tracheids of pith ray; *a*, *b*, and *c*, bordered pits of the tracheids more enlarged.

The general features of structure of coniferous woods are represented in the accompanying cut (fig 16).

The structural elements, as in all pine, are few and simple and consist of (*a*) tracheids, the common wood fibers, forming over 90 per cent of the volume; (*b*) medullary or pith rays, minute cell aggregates composed of two kinds of cells, scarcely visible without magnifier and then only on the radial section, yet forming about 7 to 8 per cent of the volume and weight of the wood in these species; (*c*) resin ducts, small passages of irregular length surrounded by resin-secreting cells, scattered through the wood, but forming two more or less connected systems, one running in the direction of the fibers, the other at right angles to the first, the individual ducts of the latter system always occupying the middle portion of medullary rays (see Pl. XXVII).

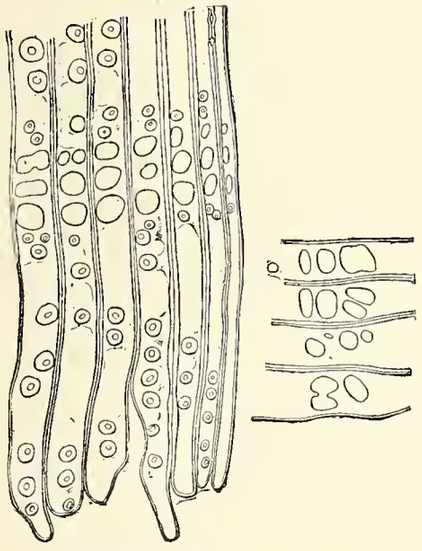


FIG. 17.—Cell endings in pine.

The tracheids, or common wood fibers, are alike in all five species, and resemble those of other pines; they are slender tubes, 4.5 to 6 mm. (about one-fourth inch) long, forty to one hundred times as long as thick, usually hexagonal in cross section, with sharp or more or less rounded outlines (see Pl. XXI), flattened in tangential direction at both ends (see Pl. XXI, A *f*), the diameter in radial direction being 45 to 55 μ (about 0.002 inch) in the springwood, and about half that, or 21 to 25 μ, in the summerwood, and in tangential direction about 40 μ on the average in their middle. They are arranged in regular radial rows (see Pl. XXI), which are continuous through an indefinite number of rings, but the number of rows increasing every year to accommodate the increasing circumference of the growing stem. (See Pl. XXI, C *c*.) The fibers of the same row are practically conterminous, i. e., they all have about the same length, though at their ends they are often bent, slightly distorted, and usually separated (see Pl. XXI, B *c*; also fig. 17), their neighbors filling out the interspaces. There is no constant difference in the dimensions of these fibers in the different species here considered. In every tree the fibers are shortest and smallest near the pith of any section, rapidly increasing in size from the pith outward, and reaching their full size in about the tenth to twentieth ring from the pith. To illustrate: In a section of Longleaf Pine, 10 feet from the ground, the diameter of tracheids in radial direction is in μ=0.001 mm:

Number of rings from center.	Spring-wood.	Summer-wood.	Average.
	μ	μ	μ
1	24	15	24
2	34	23	32
3	45	24	40
4	43	26	36
7	50	26	38
10	52	28	36
24–33	52	28	36
44–53	52	27	37

As usual in conifers, the tracheids are largest in the roots and smallest in the limbs. In these pines, especially in Longleaf Pine, they are larger in well-grown wood than in that of extremely stunted trees, though very narrow rings in otherwise normal trees do not share this diminutive size of the tracheid. (See fig. 18, A and B, where a few very narrow rings are made up of elements of normal size.)

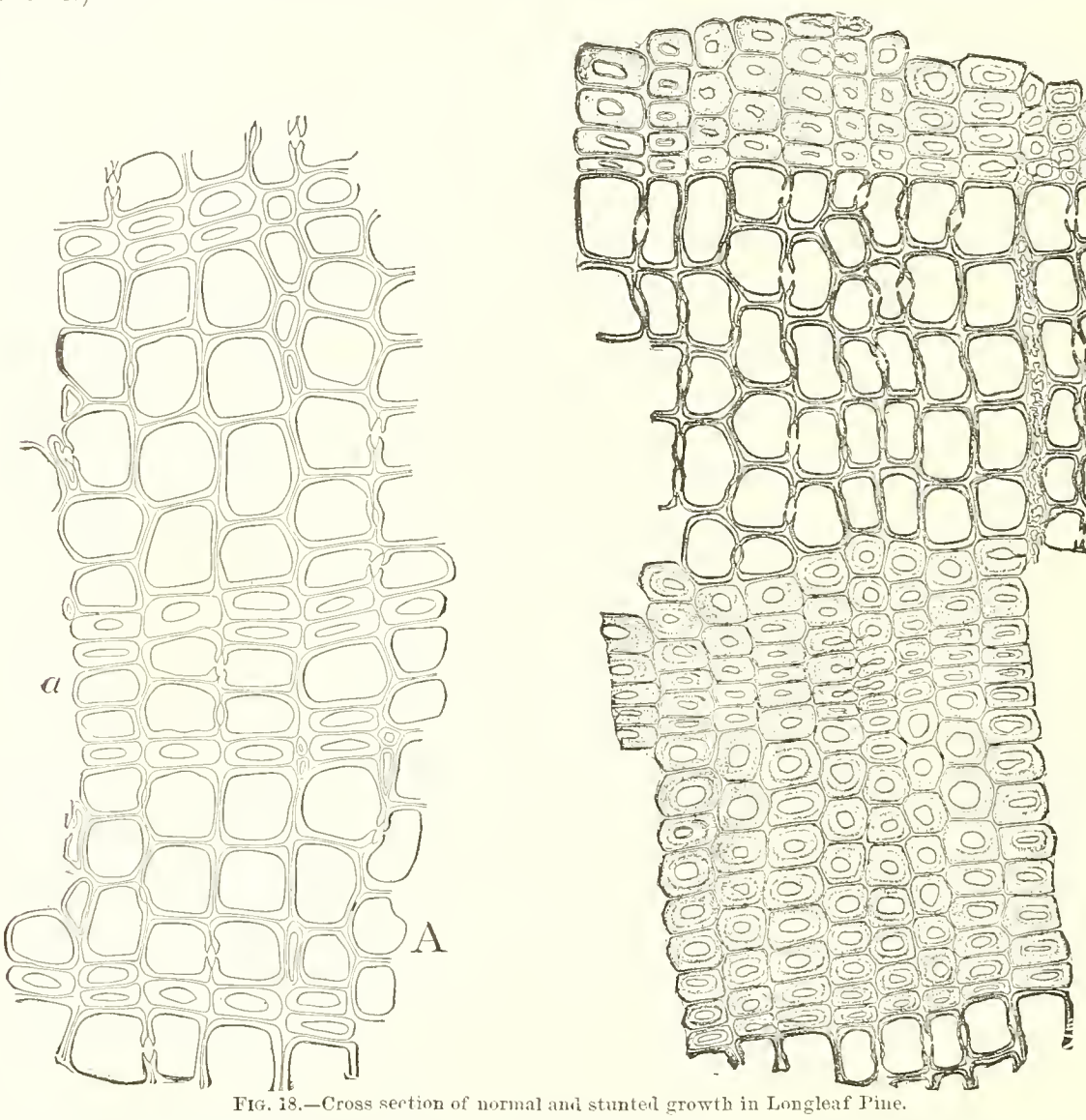


FIG. 18.—Cross section of normal and stunted growth in Longleaf Pine.

The following average figures illustrate the difference between wood from very stunted trees and that of normal trees in Longleaf Pine, of which we give an average from an extensive series examined:

Number of tree.	Age.	Average width of ring.	Radial diameter of tracheids in springwood $\mu = 0.001$ mm.	Character of tree.
		Millimeters.		
4	86	0.4–0.5	31–36	Stunted.
5	60	.4	30–36	Do.
6	70	.4	33–38	Do.
7	68	2.0	52	Normal.

As soon as the average width of the annual rings gets above 0.5 mm. the dimensions of the elements approach the normal. Thus, in trees Nos. 1 and 2, with average width of annual rings 0.5 to 0.6 mm., the average diameter of the tracheids in radial direction is 35 to 48 μ.

Normally, the diameter in radial direction is greatest in the first-formed or inner part of any ring, and decreases even before the summerwood is reached. In narrow rings with an abrupt beginning of the summerwood, so common in these Southern pines, the diameter is quite constant throughout the springwood, but changes, together with the thickness of the wall, quite suddenly with the beginning of the summerwood, thus adding to the sharpness of the outlines of the two parts. (See Pl. XXI; also fig. 18, B.) In nearly all sections there is an additional marked decrease in radial diameter in the last 3 to 5 cells of each row, which helps to emphasize the limits of the ring. In the so-called "false" rings, mentioned before, the cells of the false summerwood part resemble those of the normal summerwood. The recognition of the false ring as such rests upon the difference in shape and dimensions of the last cell rows in comparison with those adjoining. In the true summerwood the last cells are much flattened, with small lumen and somewhat reduced walls making a sharp definition toward the springwood of the next ring, which is still further accentuated by the wide lumen and thin wall of the cells of the latter. In the "false" summerwood, on the contrary, the end cells are not flattened, and the cells of the light-colored adjoining zone of wood have but a moderately wide lumen and comparatively thick walls. The fact that the outline is less regular and commonly incomplete—i. e., it does not extend around the entire section—also aids in recognizing the false rings. In the "lunes" of both limb and stem referred to above the fibers are smaller, more rounded in cross section, and commonly exhibit conspicuous intercellular spaces between them. The walls of these are often much thicker than those of the summerwood of the same ring at this point. Since the radial diameter of the fibers of the summerwood is only about half as great as that of the springwood, it is clear that the number of fibers of the summerwood forms a much greater per cent of the total number of fibers than is indicated in the per cent of summerwood given above and based upon its relative width. Thus, in wood having 50 per cent of summerwood there are, in number, twice as many tracheids in the summerwood as in the springwood.

The walls of the cells are generally about 3 to 3½ μ thick in the springwood, while in the summerwood they are 6 to 7μ thick on the tangential side and 8 to 11 μ thick on the radial side of the fiber. Generally it may be said that the thickness varies inversely as the extent of the wall, i. e., the greater any diameter the thinner the walls parallel to this diameter, which gives the impression that each cell is furnished an equal quantum of material out of which to construct its house and had the tendency of giving an equal amount to each of its four or six sides.

Generally the absolute width of the ring does not affect the thickness of the cell walls, the fibers of wide rings having no thicker walls than those of narrow rings; but when the growth of a tree is unusually suppressed, so that the rings are less than 0.5 mm. (0.02 inch) wide and each row consists of only a few fibers, the walls of the fibers of the summerwood, like those of the last-formed 2 or 3 fibers of normal rings, are thinner, so that in these cases the wood is lighter in color and weight not only because there is relatively less summerwood, but also because the fibers of this summerwood have thinner walls. (See fig. 18, A and B.) In very stunted trees, where the rings are all very narrow, the reduced thickness of the walls is counterbalanced by the smaller size of the cells.

All tracheids communicate with each other by means of the characteristic "bordered" pits. the structure of which is shown in fig. 16. These pits occur only on the radial walls of the fibers, They are most abundant near the ends of each fiber, fewest in the middle, form broken rows, single or occasionally double. (Pl. XXIII, C.) As in other pines the pits of the summerwood differ in appearance from those of the springwood. In the latter the pit appears in the cell lumen (radial view) as a perforated saucer-like eminence; in the former as a mere cleft, elongated in the direction of the longer axis of the fiber. (See Pl. XXI, B, *d* and *e*; Pl. XXIV, D, *d* and E, *a*.) In both the essential part of the pit is similar, a circular or oval cavity resembling a double convex lens, with a thin membrane dividing it into two equal plano-convex parts. (This membrane is shown only in the drawings, Pl. XXIV, D and E.) In keeping with the small radial diameter of

the fibers of the summerwood, these pits are much smaller in the summerwood than springwood, and usually are very much fewer in number.

The simple pits are in sets and occur only at the points where the fiber touches the cells of a medullary ray. (See fig. 17, also Pl. XXIV, E, sp., and other figures of this plate and Pl. XXV.) Above and below these simple pits occur very small bordered pits, communicating with those of the short transverse fibers or tracheids which form part of all medullary rays. (See Pl. XXII, D, *b. p.*)

As in all pines, the medullary or pith rays are of two kinds, the one small, 1 cell wide, and 1 to 10—in large averages 5 to 7—cells high; the other large, and each containing in the middle part a transverse resin duct. (See Pls. XXII, XXIII, XXV, and XXVII.) Of the former there occur about 21 to 27 on each square millimeter (about 15,000 per square inch) of tangential section. The second class are much less abundant and scattered very irregularly, so that sometimes areas of several square millimeters are found without any of these rays. Generally about one of these rays occurs to every 1.5 or 2 square millimeters, or about 300 to 400 per square inch of tangential section. In all rays the cell rows forming the upper and lower edge (see Pl. XXIII) are composed of short fibers or tracheids (transverse tracheids), while the inner rows contain only parenchyma cells. Occasionally small rays occur which are composed of tracheids only. (See Pl. XXII, C.) Frequently the rows of parenchyma are separated by one, rarely by two, series of tracheids (see Pl. XXIV, D, and Pl. XXV, D), giving rise to "double" or "triple" rays.

The number of cell rows in each medullary or pith ray varies from 2 to 10, on an average from 5 to 7, and of these the rows of tracheids or fibers form more than half. (See Pl. XXVI, where the outer cells or tracheids are marked with dots.)

The tracheids of the rays have thick walls covered with point-and bar-like projections, the boldest of which are on the upper and lower walls and surround the bordered pits. (See Pls. XXII and XXIII.) These short tracheids communicate with the common wood fibers, with each other, as well as with the parenchyma cells, by means of small bordered pits, which in this last case are bordered on one side (side of the tracheid) and simple on the other (half-bordered pits). The parenchyma cells occupying the inner rows of each ray communicate in the springwood part of the ring with each neighboring tracheid by 3 to 6, commonly 4 to 5, simple elliptical pits, in the summerwood by a single narrow, elongated slit-like pit (see Pls. XXII and XXIII), and with each other by small, irregular, scattered simple pits.

The walls of these cells are generally smooth, but local thickenings, especially on the upper and lower walls and surrounding the pits, occur quite frequently, though not regularly.

The parenchyma cells of the rays are usually somewhat broader and higher than the fibers, the average height for both being about 21 to 27 μ, the average width about 20 μ, while the length of each cell and fiber greater in springwood and least in the summerwood, is from two to ten times as great as the height. Assuming 25 μ and 20 μ to represent the average height and width, and allowing 25 rays of 6 cell rows each to each square millimeter of tangential section, then the rays form about 7.5 per cent of the total volume and weight of the wood of these species. An attempt to utilize for purposes of identification the difference in the number, size, and distribution of these rays, or the proportion between the number of rows of tracheids and those of parenchyma cells, as was done by Dr. J. Schroeder,[1] has not been successful, and appears of little promise.

The large rays with transverse resin ducts resemble the smaller rays described. On Pl. XXV at A such a ray is seen both in radial and tangential section. Series of transverse tracheids occupy the upper and lower edge, but the interior, unlike that of common rays, is several cells wide, and contains an open duct in its widest portion. (See Pl. XXVII, *r. d.*) This duct is commonly more or less filled with resin (see Pl. XXVII, E); it is surrounded by thin-walled secreting cells, and, in the heart wood, often divided or filled up by thylosis, i. e., by very thin walled, much puffed out cells, growing out of the surrounding secreting cells before the latter perish.

The walls of the secreting cells are quite thin, those of the remainder of the parenchyma vary to some extent in the different species. In the Longleaf and Loblolly Pines the walls of the parenchyma composing the principal part of the ray are generally quite thick (see Pl. XXVII, A–E),

[1] Dr. Julius Schroeder, Das Holz der Coniferen, Dresden, 1872.

thicker than those of the cells of ordinary rays, and especially thickened near the simple pits by which these cells communicate with each other. In Cuban and Shortleaf this thickening is much less conspicuous, and absent entirely in many cases (see Pl. XXV, A), while in the Spruce Pine it seems wanting altogether.

These ducts exist even in the very first ring (next to the pith), are smaller and more numerous near center, but have essentially the same structure in the wood of the fifth and later years.

The tracheids of the pith rays are wanting next to the pith, but occur in all rays in the outer part of even the first ring. The rays in this ring are generally lower, composed of fewer cell rows, but the cells are larger than in the rest of the wood.

Both shape and size of these medullary rays are very variable; an average of about 0.4 mm. for the height of the ray and 60 μ for the width at the resin duct was observed. An attempt to utilize the shape, especially the appearance of the two edges, as a means of separating the wood of these species has so far failed entirely.

The large resin ducts running lengthwise in the wood or parallel to the common wood fibers are much larger than the transverse ducts, measuring, inclusive of the secretive cells, on an average about 0.2 mm. (0.008 inch) on their smaller radial diameter and about 0.3 mm. on the tangential. (See Pl. XXI, A, *r. d.*) They are usually situated in the summerwood of each ring, often in narrow rings, causing an irregular outline. They are smaller and more numerous near the pith, here usually forming several series in one annual ring, more numerous in wide rings than in narrow ones, but their number per square inch of cross section as well as their dimensions appear to be independent of the width of the rings. In their structure they resemble those of other pines. They are surrounded by thin-walled resin-secreting parenchyma, part of which often appears as if not directly connected with the duct. (See Pl. XXI, A.) In many cases all the tissue between two neighboring ducts is of this parenchyma. Longitudinal and transverse ducts frequently meet and thus form a continuous network of ducts throughout the wood.

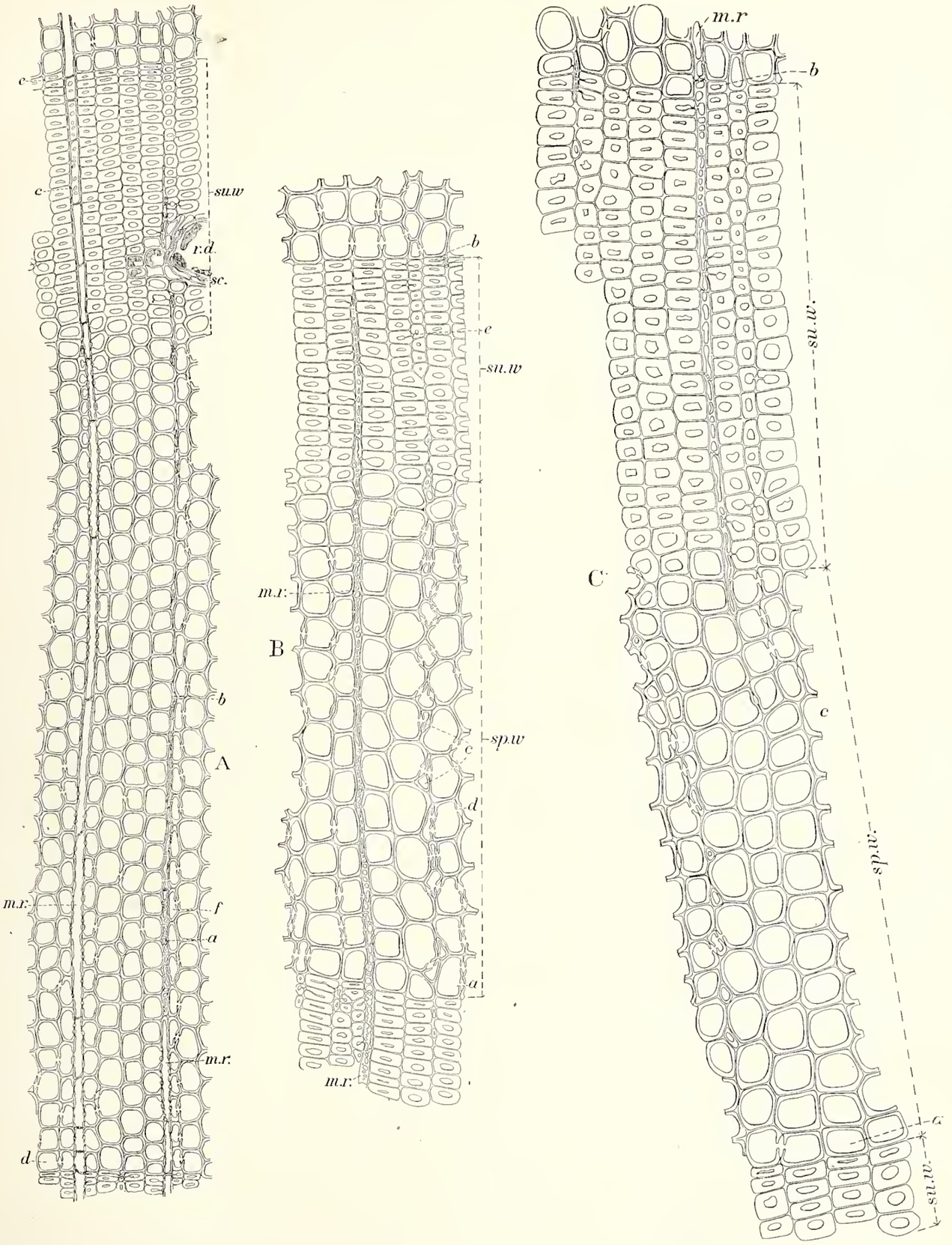
PLATE XXI.—CROSS SECTIONS.

A, PINUS TEDA, $\frac{75}{1}$. *r. d.*, resin duct; *s. c.*, secreting cells; *m. r.*, medullary rays; *a*, section of transverse tracheid of ray; *b*, the ray leaves the plain of the section at this point, small parts of it reappearing further on; *c*, simple pits connecting parenchyma cells of the ray; *d–e*, part of a row of tracheids formed during one season; *f*, flattened terminal part of a tracheid.

B, PINUS HETEROPHYLLA, $\frac{100}{1}$. *sp. w.*, springwood; *su. w.*, summerwood; *a–b*, part of a row of tracheids formed during one season; *c*, terminal parts of tracheids; *d*, bordered pit in springwood; *e*, same in summerwood; other letters as in *A*.

C, PINUS GLABRA, $\frac{150}{1}$. *c*, row of tracheids doubled; other letters as in *B*.

Originals, all $\frac{300}{1}$.



TYPICAL CROSS SECTIONS OF PINUS TÆDA, HETEROPHYLLA, AND GLABRA.

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PLATE XXII.

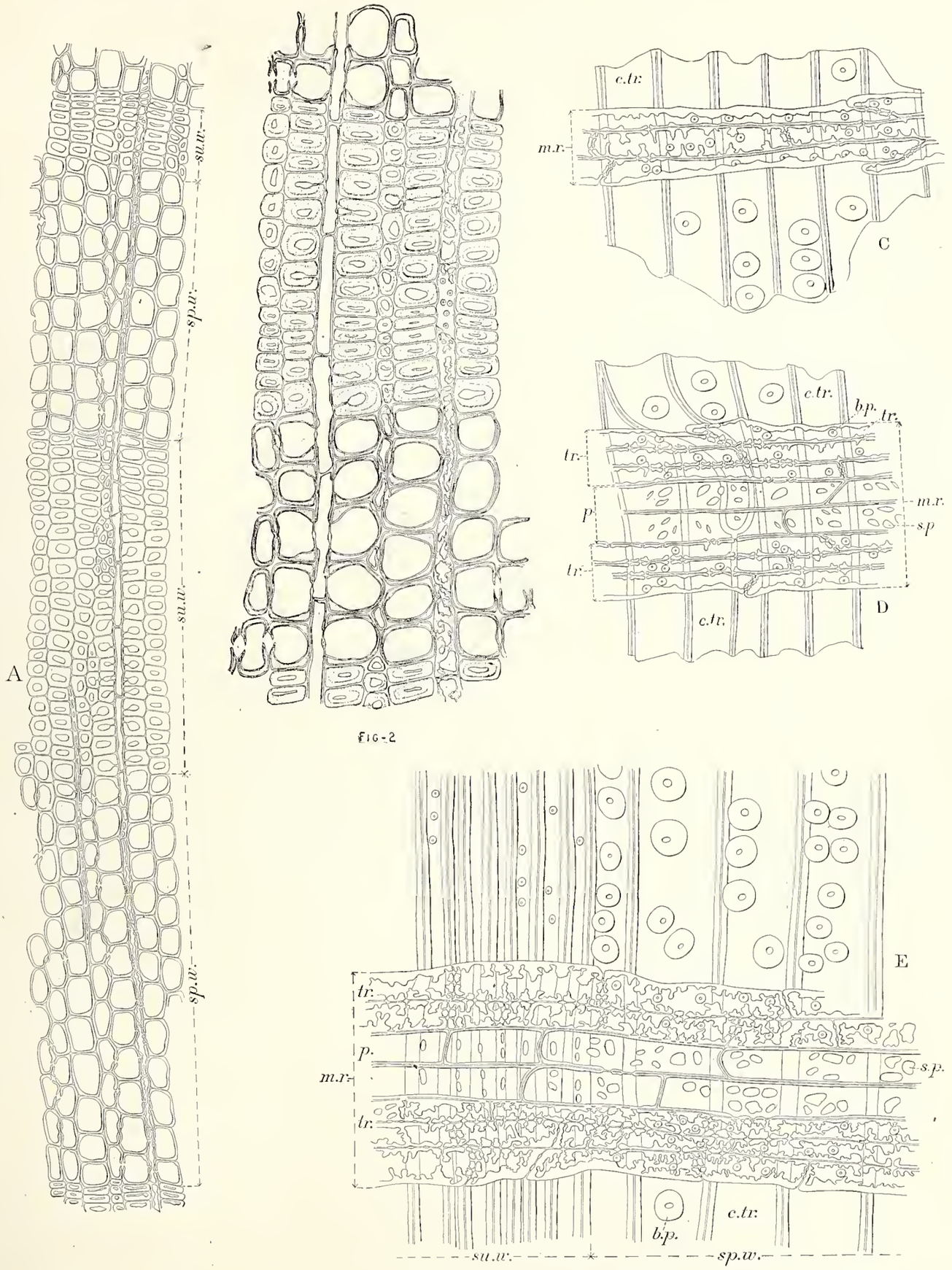
A, PINUS ECHINATA. Cross section of two rings; *sp. w.*, springwood; *su. w.*, summerwood.

B, PINUS PALUSTRIS. Cross section of a very narrow ring. Of the two medullary rays one is cut through a row of parenchyma, the other through a row of tracheids.

C and *D*, PINUS GLABRA. Radial sections; *m. r.*, medullary rays; *tr.*, tracheids of the medullary rays; *p.*, parenchyma of the same; *s. p.*, simple pits leading from the parenchyma to the neighboring tracheids or common fibers *c. tr.*; *b. p.*, bordered pit. The ray at *C* is made up of tracheids only.

E, PINUS PALUSTRIS. Radial section; lettering as in *D*.

Originals magnified: *A*, $\frac{300}{1}$, the rest $\frac{500}{1}$; illustrations: *A*, $\frac{100}{1}$, the rest $\frac{200}{1}$.



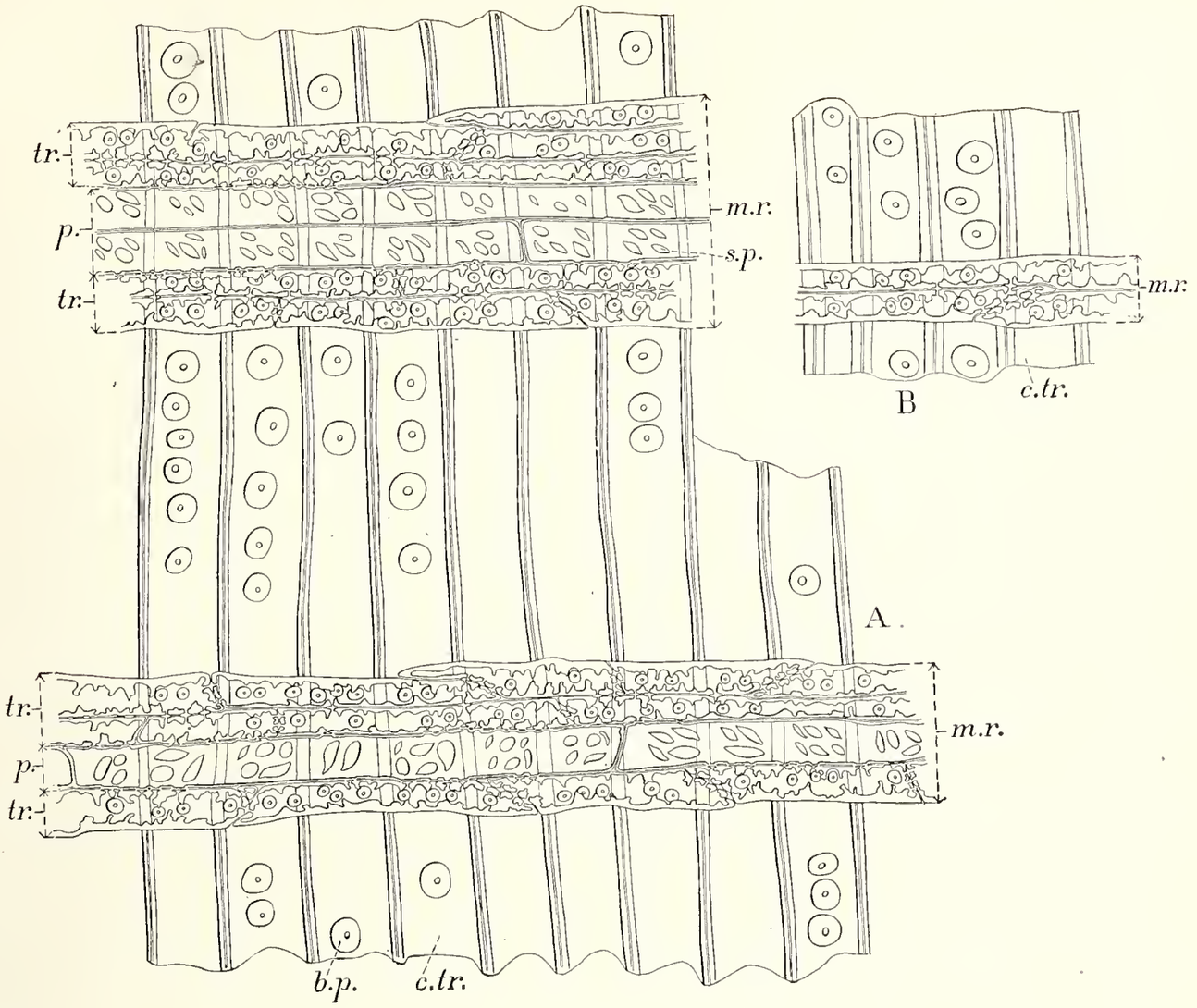
TYPICAL CROSS SECTIONS OF PINUS PALUSTRIS AND ECHINATA, AND RADIAL SECTIONS OF PINUS PALUSTRIS AND GLABRA.

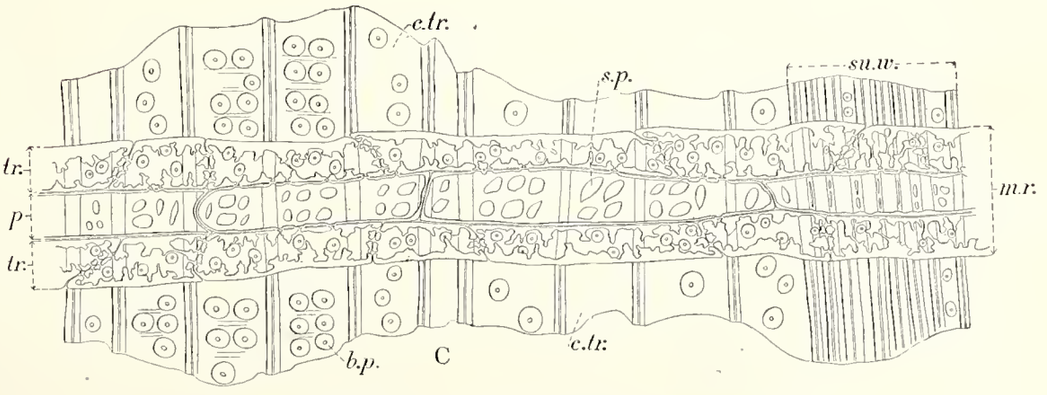
PLATE XXIII.—RADIAL SECTIONS.

A and *B*, PINUS ECHINATA. *m. r.*, medullary rays; *p.*, parenchyma of same; *tr.*, transverse tracheids of rays; *s. p.*, simple pits; *b. p.*, bordered pits; *c. tr.*, common tracheids.

C, PINUS HETEROPHYLLA. *su. w.*, summerwood; other letters as in *A*.

Originals magnified $\frac{500}{1}$; illustrations, $\frac{200}{1}$.





RADIAL SECTIONS OF PINUS ECHINATA AND HETEROPHYLLA.

PLATE XXIV.—RADIAL AND TANGENTIAL SECTIONS.

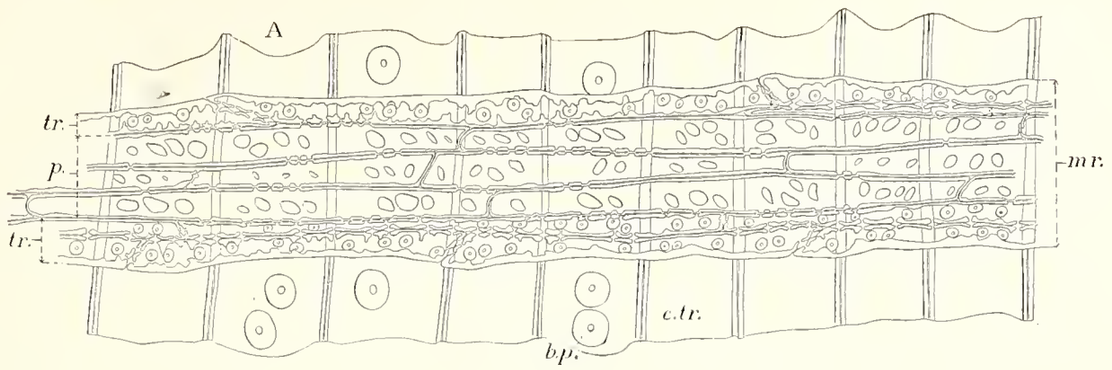
A and *B*, PINUS TEDA. Radial sections; *m. r.*, medullary rays; *tr.*, tracheids; *p.*, parenchyma of the rays; *s. p.*, simple pit; *b. p.*, bordered pit; *c. tr.*, common tracheids.

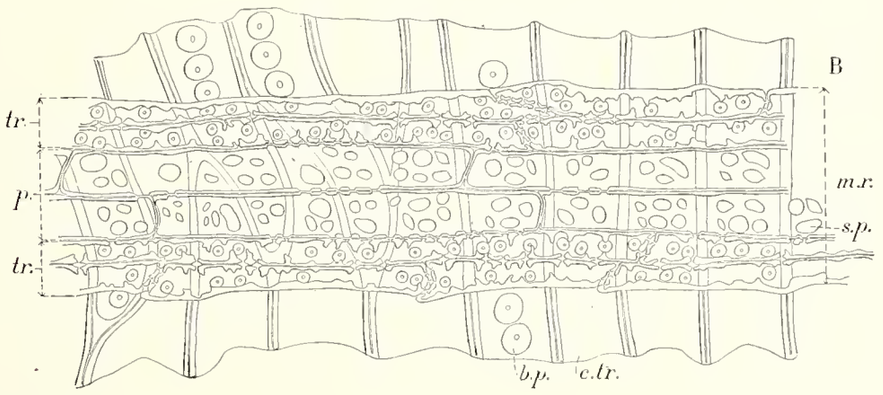
C–E, tangential sections.

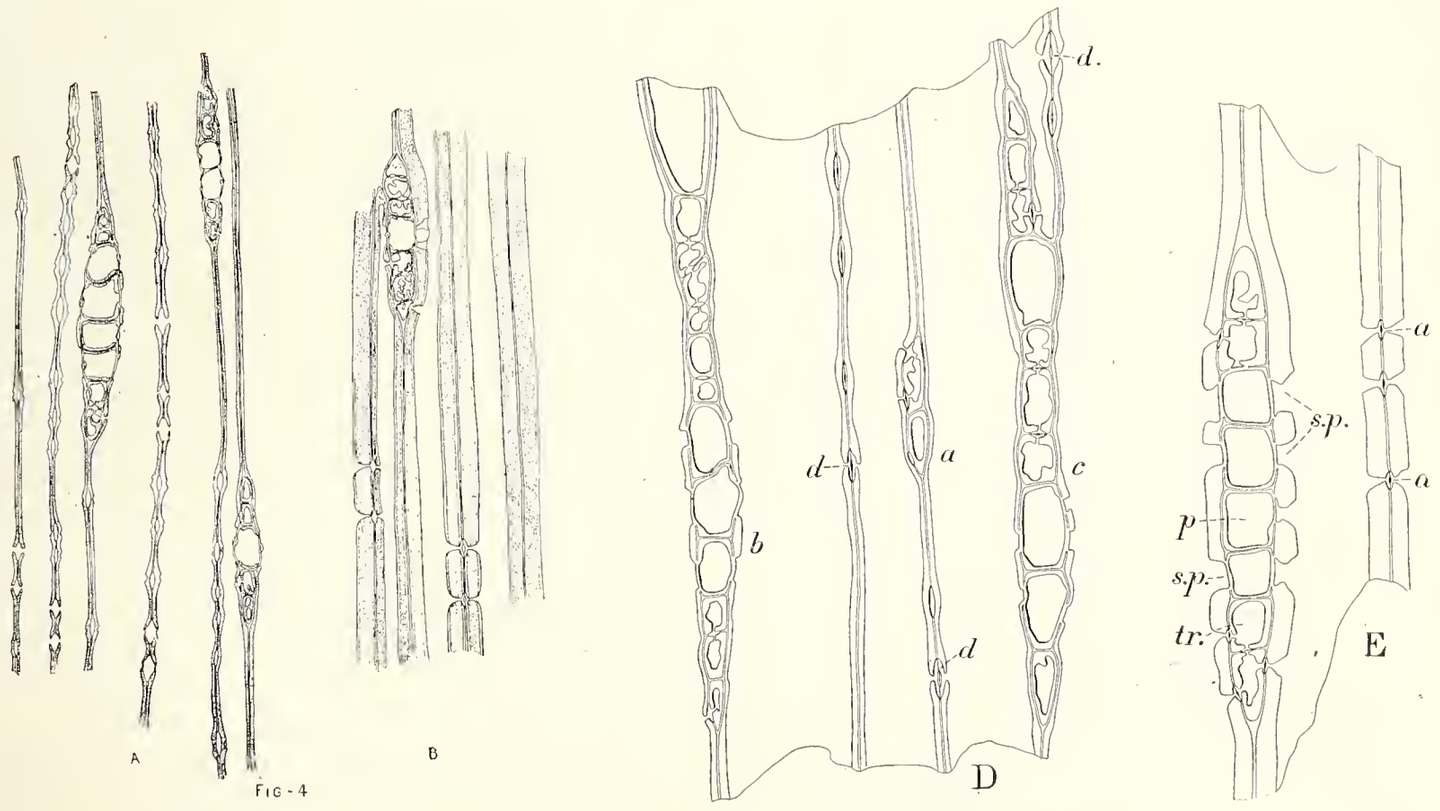
C, PINUS PALUSTRIS. Left-hand part in springwood, right-hand portion in summerwood.

D–E, PINUS ECHINATA. *D*, Section in springwood; *a–c*, medullary rays; *a*, a small ray composed of tracheids only; *c*, a "triple" ray; *d*, bordered pit showing the membrane in place. *E*, Section in summerwood; *a*, bordered pit, other letters as in *A* and *B*.

Magnification of originals, $\frac{500}{1}$; of illustrations: *A* and *B*, $\frac{200}{1}$; *C–E*, $\frac{300}{1}$.







RADIAL SECTIONS OF PINUS TÆDA AND TANGENTIAL SECTIONS OF PINUS PALUSTRIS AND ECHINATA.

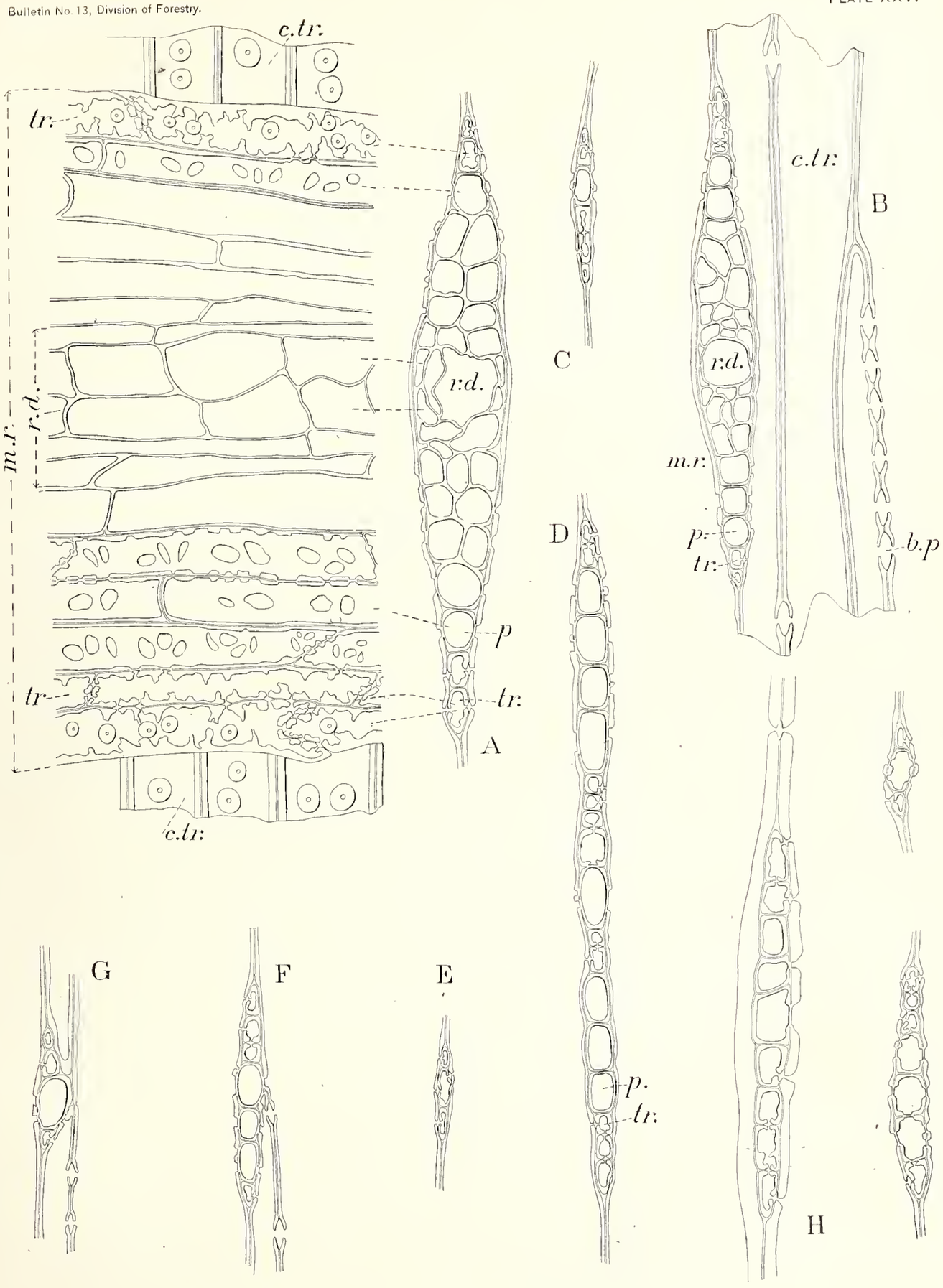
PLATE XXV.

A, PINUS HETEROPHYLLA. Radial and tangential sections of a transverse resin duct; *r. d.*, resin duct; *m. r.*, medullary ray; *tr.*, tracheids of the medullary ray; *p.*, parenchyma cells of the same; *c. tr.*, common tracheids or wood fibers.

B–G, PINUS GLABRA. *B*, tangential section of a transverse resin duct and parts of three fibers; *b. p.*, bordered pit; other letters as above; *C–G*, tangential sections of medullary rays, of which *E* is made up of tracheids only, while *D* is a "triple" ray.

H, PINUS TEDA. Tangential sections of medullary rays in spring and summer wood.

Original magnified 500 times, illustrations about $\frac{300}{1}$.



TANGENTIAL SECTIONS OF PINUS TÆDA, HETEROPHYLLA, AND GLABRA.

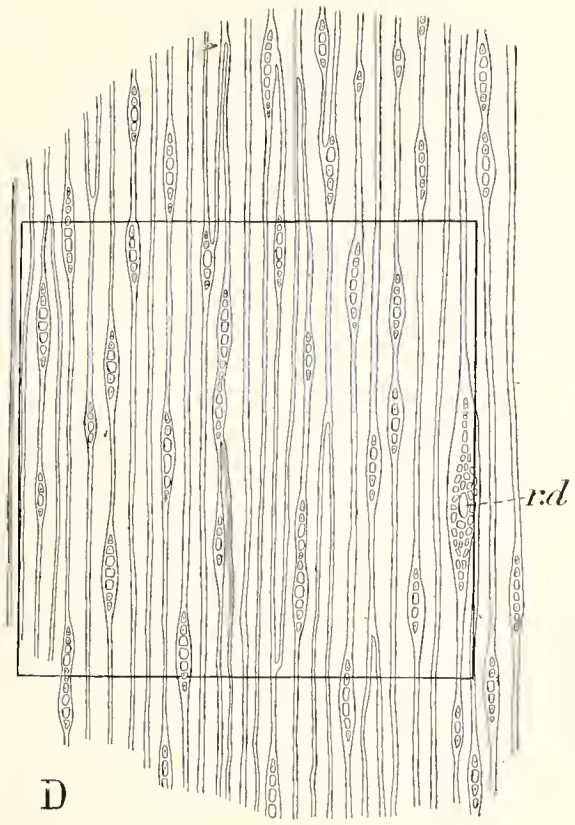
PLATE XXVI.—TANGENTIAL SECTIONS.

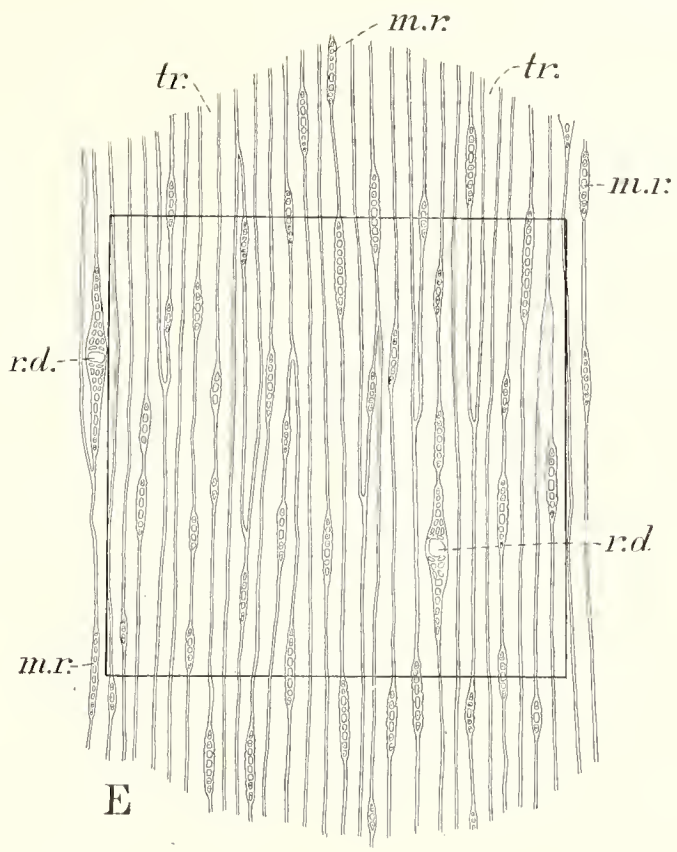
A–C and *F*, PINUS HETEROPHYLLA. *D*, PINUS ECHINATA. *E*, PINUS GLABRA.

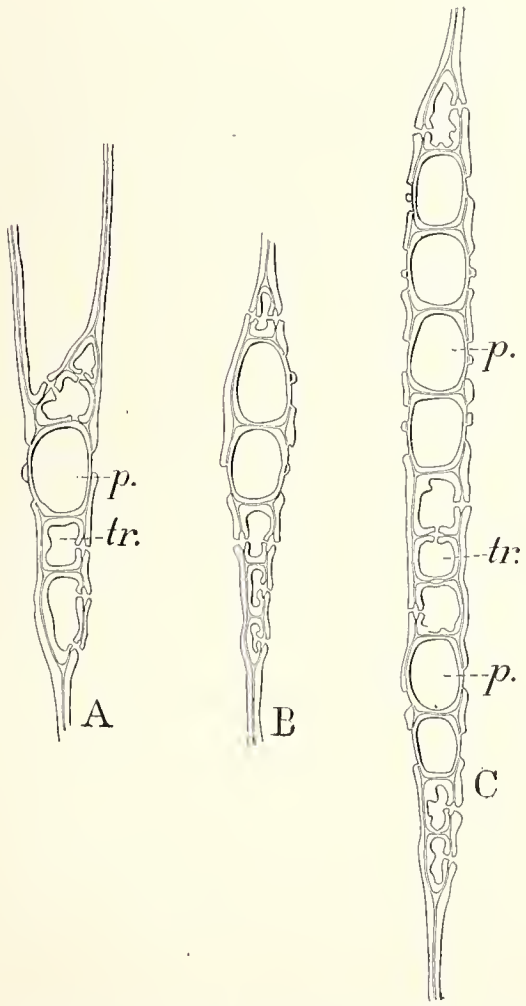
A–C, sections of medullary rays; *tr.*, tracheids; *p.*, parenchyma; *C* is a "double" ray.

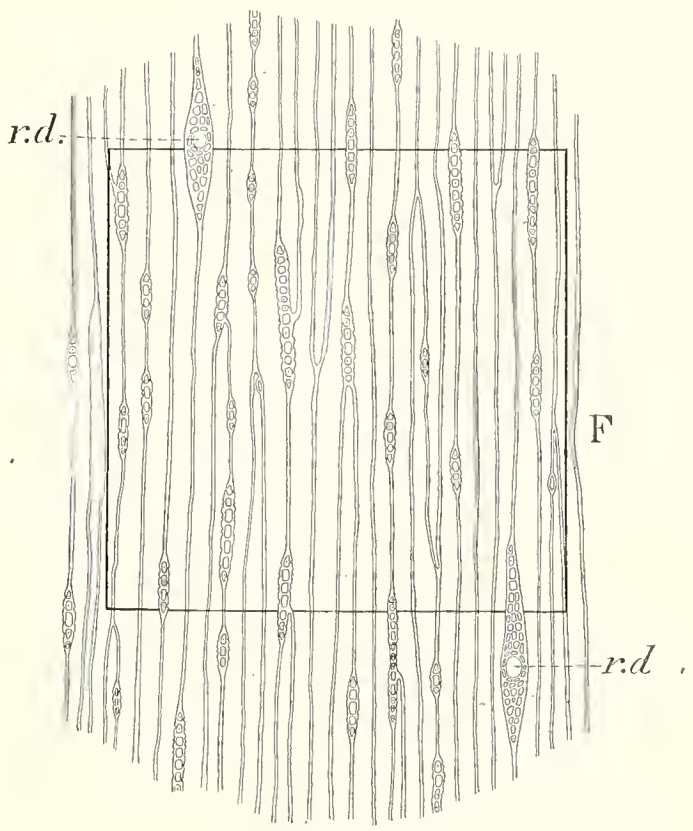
In *D–F*, histological details are omitted; they are camera drawings showing number and distribution of medullary rays, and also the proportion of the tracheids to parenchyma in each ray, the former being indicated by dots; *r. d.*, transverse resin ducts; *m. r.*, medullary rays.

Magnification of originals: *A–C*, $\frac{500}{1}$; *D–F*, $\frac{85}{1}$; of illustrations: *A–C*, $\frac{300}{1}$; *D–F*, $\frac{85}{1}$.







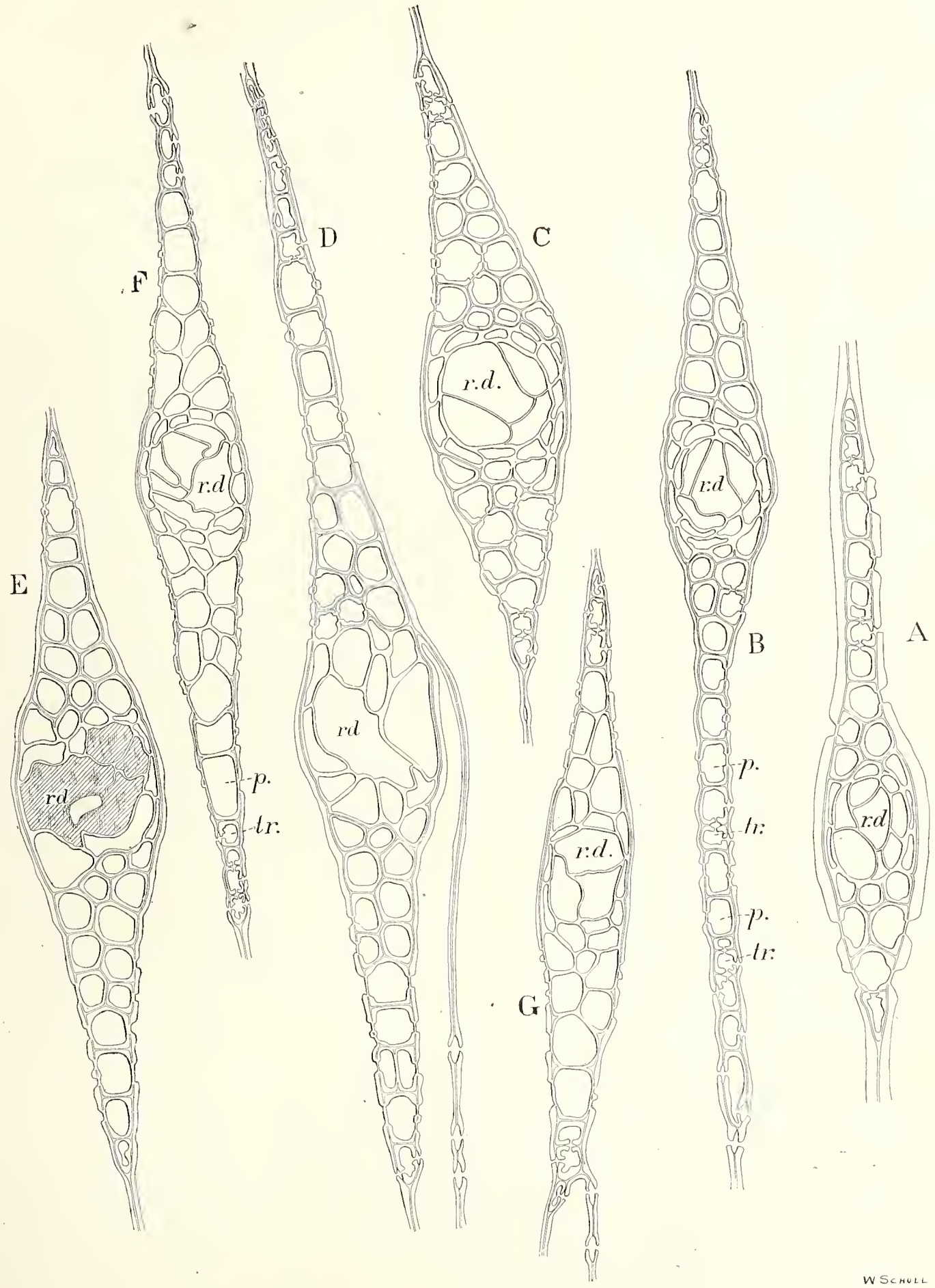


TANGENTIAL SECTIONS OF PINUS ECHINATA, HETEROPHYLLA, AND GLABRA, SHOWING NUMBER AND DISTRIBUTION OF PITH RAYS AND PROPORTION OF PITH-RAY CELLS.

PLATE XXVII.—TANGENTIAL SECTIONS OF TRANSVERSE RESIN DUCTS.

A–C, PINUS TÆDA. *D* and *E*, P. PALUSTRIS. *F*, P. ECHINATA. *G*, P. HETEROPHYLLA. *r. d.*, resin ducts; *tr.*, transverse tracheids: *p.*, parenchyma.

Magnification of originals, $\frac{500}{1}$; of illustrations, $\frac{300}{1}$.



TRANSVERSE RESIN DUCTS—TANGENTIAL VIEWS.

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